Route to:

Return to:

# INSTITUTE OF GAS TECHNOLOGY

THE GAS INDUSTRY'S OWN EDUCATIONAL AND RESEARCH FACILITY

CHICAGO 16, ILLINOIS

# GAS ABSTRACTS

SEPTEMBER, 1961

VOLUME 17 NUMBER 9

AFFILIATED WITH

ILLINOIS INSTITUTE OF TECHNOLOGY

# CONTENTS


1. **Management**—Gas industry progress, business problems, statistics, government regulation, safety, personnel, education..... 201

2. **Energy Supply and Economics**—Resources, reserves, and competitive applications of the fossil fuels and other sources of energy, including nuclear and solar energy..... 204

3. **Natural Gas and Petroleum Production**—Geology, exploration, drilling, well management, reservoir engineering..... 207

4. **Gas Conditioning and LPG Recovery**—Condensate, dust, $CO_2$ and sulfur removal, dehydration, odorization, oil fogging, humidification; LPG recovery and refining..... 210

5. **Natural Gas Transmission**—Pipelines, compressors, dispatching, flow regulation, communications, maintenance..... 211

6. **Gas and LPG Storage**—Holders, pressure tanks, underground storage; liquefaction, refrigerated storage..... 213

7. **Manufactured Gas and Chemical Processing**—Gasification of coal, oil; reformed gas; chemical treatment; byproducts; synthesis gas production and conversion; petrochemicals; catalysts, catalyst development..... 214

8. **Gas Distribution**—City utility systems: design, operation, maintenance; weather influence on peak loads and supply; LPG-air mixtures..... 217

9. **Gas Fuel Utilization and Appliances**—Domestic, commercial, industrial; burners; combustion research; air pollution..... 218

10. **Equipment and Instrumentation**—Production and handling equipment, and maintenance; computers; controls; measurement..... 222

11. **Materials of Construction, and Corrosion**—Metals, refractories, plastics; corrosion measurement, prevention..... 223

12. **Analytical Methods and Tests**—Standard and research techniques for gas-making materials, products, processes; instrumental analysis..... 225

13. **Basic Science**—Chemistry, physics and basic engineering related to gas technology; physical properties of gases: phase equilibria, thermodynamics, reaction kinetics, heat and mass transfer, fluid flow..... 227

**Services Available to Readers**—Photocopies, microfilm, Russian translations, bibliographies and literature searches, *Gas Abstracts on Cards*, back numbers of *Gas Abstracts*.....**Inside Back Cover**

**Publications Abstracted for Gas Abstracts**.....**Back Cover**



O. P. BRYSCH, Editor P. J. CHATTA, Assistant Editor P. VAN ARSDELL, Assistant Editor

GAS ABSTRACTS is published and distributed monthly by the Institute of Gas Technology, Chicago 16, Illinois. The contents of selected papers and patents are reviewed impartially by the editorial staff and material of potential interest to the Gas Industry is presented.

Subscription rates to nonmembers of the Institute: $18.00 per year to U. S. addresses; $22.00 foreign. Regardless of the month in which it is entered, each subscription starts with the January issue. A gold-stamped fabrikoid binder for the year, and title- and end-pages for that volume, are sent with the January issue. A complete index to the year's issues is mailed as soon after the year's end as it can be prepared, edited and printed.


Copyright 1961 by the Institute of Gas Technology. Printed in the U.S.A.


A microfilm edition of Gas Abstracts can be supplied by University Microfilms, 313 N. First St., Ann Arbor, Michigan.

## 1. MANAGEMENT

### Gas Industry Management

**Gas Industry Group to Study Long Range Supply Needs.** *Pipe Line News 33,* 17 (1961) Aug. (2 pp.); **Gas Hails New Gas Requirements and Supply Group.** J. F. Ebdon. *Gas 37,* 58 (1961) Sept. (3 pp.)

Significant long-range planning step has been taken by the nation's gas utility industry with the formation of a special task force to measure future supply and demand. A newly organized Committee on Gas Requirements and Supply, working through the general management section of the American Gas Association, includes leading executives of transmission, distribution and producing companies. The committee will be divided into two segments—gas requirements and gas supply. Confidential information collected nationally will be analyzed, summarized and reported periodically to the industry. The gas requirements segment of the new committee has already been named, with two men serving in each of ten geographical areas. The gas supply segment, to be completed, will include members representing producers, pipeline companies, exploration companies and geological firms.

### Gas Industry Expansion

**Gas Heating Customers Up 1.2 Million in 1960; Total Now Record 21,350,000.** *Gas Age 128,* 32 (1961) Aug. 17 (3 pp.)

More homes are being heated with gas in the United States than ever before, with an additional 1,171,000 customers added to the industry's customer lists last year. There were 21,352,000 customers heating with gas at the close of 1960, an increase of 5.8% over the previous year, according to A.G.A.'s annual gas house-heating survey. The survey predicted that in the three-year period ending in 1963, more than 3,564,000 new gas heating customers will be added. New customers accounted for 62% of gas heating installations in 1960. The remaining 38% made conversions from other fuels.

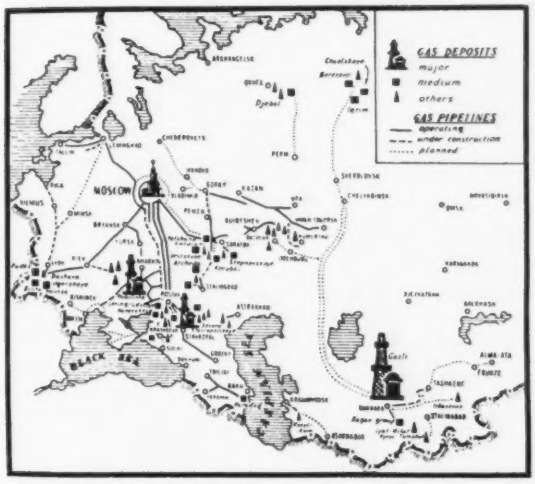
**From Canada to California—Pacific Gas and Electric Builds a Line.** J. F. Ebdon. *Gas 37,* 57 (1961) Aug. (12 pp.)

Author reviews history of Pacific Gas & Electric Co. (San Francisco), beginning with its inception in 1854, when it was the San Francisco Gas Co. Its consolidation with the Edison Light and Power Co., in 1896, created the San Francisco Gas and Electric Co. In 1906 it assumed its present name, and gained control of the San Francisco company as well as of the California Gas and Electric Corp. The effect of the earthquake of 1906 and the advent of natural gas in 1920 also are discussed. Article concludes with notation that in order to serve its present and anticipated load, the company is tapping fields in Alberta, Canada, via a 36-in. pipline.

**Alaska Greets the Gas Man.** *Business Week No. 1669,* 94 (1961) Aug. 26 (2 pp.)

Utility owned by Texans, the Anchorage Natural Gas Co., is delivering to the first natural gas customers in any major Alaskan city. A subsidiary of the Alaska Pipeline Co., utility, is bringing natural gas to Anchorage from wells in Kenai, 85 miles to the south. Thus ends a 2½-year race that almost failed because of an 8½-mile crossing at Turnagain Arm, an estuary notorious for violent currents, strong winds and tides of 30 ft or more.

**USSR Gas Industry—Today and Planned for 1965**




(*How the U.S. and U.S.S.R. Gas . . .* see abstract, p. 202. From *Pipe Line Industry,* Copyright 1961)

**Gas Processing and Refining: 75 Construction Projects in the Works.** *Oil Gas J. 59,* 159 (1961) July 31 (6 pp.)

New refineries and crude unit replacements are included in the current refinery building activity. More than 35 refinery projects of various types are under construction or planned in the United States and Canada. Alaska's increasing crude production (now at more than 19,000 bbl/day) sparked plans for two new plants. In gas processing construction, the 40 projects now under way or planned include Shell's recently announced plant near Yscloskey, La., about 30 miles southeast of New Orleans. It will have a capacity of 650 MMCF/day.

### Air Pollution

**An Evaluation of Natural Gas in Reducing Industrial Air Pollution.** S. S. Grieswold, R. L. Chass, R. E. George, and R. G. Holmes. *Gas Age 128,* 36 (1961) July 20 (4 pp.)

Studies conducted by the Los Angeles Air Pollution Control District show these problems to be caused by burning of fuel oil: 1) the occurrence of esthetically offensive visible plumes which, much of the time, are also in violation of Section 24242 of the California Health and Safety Code; 2) generalized reductions in visibility traceable to atmospheric reactions involving sulfur oxides, hydrocarbons, and oxides of nitrogen; 3) damage to vegetation which has been traced to contaminant emissions from fuel oil burning; and 4) widespread nuisance to a substantial percentage of the residents of Los Angeles County as evidenced by formal registry of

complaints regarding eye irritation, throat irritation, effects on people afflicted with respiratory ailments, and general discomfort.

### Ammonia

**Ammonia Producers Set for More Capacity.** *Chem. Eng. News 39,* 33 (1961) Aug. 14 (3 pp.)

Anhydrous ammonia industry expects several more expansions to be announced before its current round of capacity buildup tapers. These will be in addition to the 1.1 million tons of annual capacity completed or under construction so far this year. Capacity operation of existing plants this past spring and the continuing growth of nitrogen fertilizer demand make it plain that the industry is ready for another big upsurge in capacity.

### Aromatics

**Petroleum Aromatics: From Specialty Operation to $350-Million-a-Year Industry in 10 Years . . . What's Ahead?** G. Adams and B. G. Casteel. *Oil Gas J. 59,* 171 (1961) Sept. 4 (4 pp.)

Aromatic chemicals from petroleum sources now represent the major source of supply for benzene, toluene, and xylene chemicals. Napthalene is one of the few aromatics still dominated by the coal-tar industry. However, hydrodealkylation processes threaten to shift the major source of naphthalene to petroleum before the end of 1962. Benzene leads the aromatics field in volume and value. Toluene continues to be the poor relation in the aromatics family. Interest in separating xylenes for chemical sales is mounting, with orthoxylene production capacity skyrocketing to reflect its emergence as a favored phthalic anhydride feed stock. Recovery of paraxylene and ethylbenzene from mixed xylene should increase. The development of dependable, high-quality, low-price petroleum aromatic chemicals has encouraged the rapid development of many new aromatic products. Article forecasts bright future.

### Cost Accounting

**Bibliography of Investment and Operating Costs for Chemical and Petroleum Plants, January-December 1960.** S. Katell, J. H. Faber and M. J. Williams. *U. S. Bur. Mines Inf. Circ. 8035* (Washington, D. C.: U.S. Govt. Print. Off. 1961; 96 pp. $0.50)

Cost bibliography, covering the period from January through December 1960, is a continuation of the series which began in October 1949. It is also the second report in the series to be prepared as an annual cooperative effort by the Bureau of Mines and the American Association of Cost Engineers. Items on methods, theory, computer use, foreign data, indexes, and energy are included.

**Preliminary Cost Estimating for Processing Equipment Installations.** W. O. Dietsche. *Cost Eng. 6,* 10 (1961) July (6 pp.)

Article presents cost data on installation of chemical process equipment obtained from major expansions in chemical plant production facilities. Data demonstrates the cost of each phase of an installation relative to the total cost. From these data the approximate total cost and costs of all phases of a project can be obtained by knowing the cost of any one part.

### Education

**Power Survey Shows 447 Educational Opportunities in Instrumentation and Process Control.** S. Elonka. *Power 105,* 69 (1961) Sept. (10 pp.)

Author presents extensive survey of courses offered by various organizations in instrument and process control. Tabulated information shows names and addresses of instrument manufacturers, correspondence schools, extension courses, trade and vocational schools, technical institutes, junior colleges and undergraduate and graduate schools, each of which offers one or more courses in this field.

### Federal Power Commission

**The Federal Power Commission. Part 3. What's in Store?** N. Regeimbal. *Gas 37,* 55 (1961) Sept. (3 pp.)

Possibilities for change in the FPC are discussed. Some of the changes are agreeable to all but the major problem, that of clearing up huge case backlogs, has no clearcut solution. Some of the problems of concern to the gas industry are presented in this final article of the series.

### Foreign Activities

**How the U. S. and U.S.S.R. Gas Industries Compare.** D. M. Taylor (based on an interview with B. Goodrich). *Pipe Line Ind. 15,* 59 (1961) Sept. (5 pp.)

Member of the 10-man American gas team who participated in a 30-day tour of Russia gives observations on the Soviet gas industry. Gasfields, wellheads, compressor stations, pipeline construction and town distribution projects were visited. Practice in general follows that in the United States, with some striking disparities in construction and exaggerated emphasis on the 1965 planned results. Some 25,000 miles of pipeline and 5 trillion CF gas production are planned for 1965. Two 40-in. lines—Krasnodar to Moscow and Gazli to Sverdlovsk—as well as a triple-ring distribution system for Moscow, are under construction.

**Oil Is Vital to Mexico.** P. G. Roldan. *World Petrol. 32,* 42 (1961) Sept. (4 pp.)

Petroleos Mexicanos is an example of coordination of activity between private and public capital. By giving birth to the petrochemical industry, and by consuming large quantities of steel and other national products, Petroleos Mexicanos finds itself in a central position at the base of the new Mexico economy. The excellent perspectives of the petroleum industry, and the possibilities of future economic development of the country, have opened the doors of international bank credit to Petroleos Mexicanos and to other enterprises, public and private. Outlook is discussed.

**Russia's Oil Drive.** G. W. Reed. *World Petrol. 32,* 54 (1961) Sept. (3 pp.)

Russia claims only a fraction of the total international crude export market, but that fraction is a disturbing one.

Russian sales have upset the market and threaten to wreck the international crude price structure if action by consuming nations is not forthcoming. Russian foreign exchange comes largely from raw materials in excess supply. If Russia chooses to sell at dump prices, says author, a quota limitation in the case of oil should be placed on her shipments to protect the Arabs. The price rather than the volume of Russian oil shipments is the most disturbing factor. A table of Russian oil shipments to various markets is appended.

**Some Considerations of Gas Making in Terms of the National Fuel Situation for the Next 25 Years.** M. W. Thring and C. Hulse. I.G.E. Comm. No. 581; *Inst. Gas Eng. J. 1,* 493 (1961) July (5 pp.); **Presentation, Discussion and Reply.** 497 *Ibid.,* July (5 pp.)

Several economic processes for total gasification of oil are available. Such processes may be expected to form a permanent feature of the gas industry, and, in the long term, are desirable from the point of view of conservation of world fuel resources. It seems likely that valuable fuel potential based on petroleum would be wasted if some of it were not converted to gas. The only process currently capable of commercial application to coal is the Lurgi, using a fixed bed and an oxygen/steam blast. It is restricted to economic operation of large units, operating at high load factor, near, or preferably at, the pithead. Since it operates at high pressure, it is eminently suited to supplying a gas grid, in which gas may be transported over great distances.

**Summing Up Germany's Chemical Boom.** *Chem. Week 89,* 81 (1961) Aug. 19 (3 pp.)

U. S. producers can now take a detailed look at the trends that brought on West Germany's 1960 chemical industry boom. A newly available U. S. government report shows production and trade figures for the major chemical groups and for many specific commodities, and discusses the factors behind the important trends. With production up 14.6%, and sales rising 12% above the '59 levels, Germany's chemical boom was pretty much across-the-board. Gains were made in all industry sectors. Sales, production, exports, imports and investment all scored record highs. Germany easily held its place as the world's fourth largest producer of chemicals.

## Petrochemicals

**Petrochemicals: Reasons to Be Bullish.** *Can. Chem. Processing 45,* 48 (1961) Aug. (4 pp.)

The U. S. President's Materials Policy Commission in 1952 predicted an early maturity for petrochemicals. A growth rate of 8% for the '55-'60 period was to be followed by a 5% pace in '60-'65, 4% in '65-'70 and 3½% in '70-'75. The Research Council of Alberta in 1955 accepted that pattern, allowing a 5-year lag for Canada. Not only have these estimates proven conservative in the short run (gross value of petrochemicals has risen at an annual rate of 12% in Canada), but the 10- and 20-year projections are equally on the low side. The best figure on total Canadian output for 1960 is $244 million. The outlook is that a 15-18%/annum hike is in the cards for the next five years, and that gross value should fall within the $450-$475 million range by 1965.

**1961 Survey of U. S. Petrochemical Plants.** *Oil Gas J. 59,* 122 (1961) Sept. 4 (34 pp.)

More than 190 companies are manufacturing, or will soon be manufacturing, petrochemical products in the United States. Survey lists more than 400 operating petrochemical plants. About 90 new construction or expansion programs are under way or planned, with the Gulf Coast the busiest area. Plant-by-plant listing of U. S. facilities and construction is given.

**Petrochemical Plants Outside the U. S.** *Oil Gas J. 59,* 139 (1961) Sept. 4 (19 pp.)

Construction projects as well as operating plants in 40 countries are included in new survey of petrochemical facilities in the free world outside the United States. Report lists more than 300 operating plants, of which about 175 are in Europe. More than 200 construction projects are under way or proposed. These include projects at new sites as well as expansion programs.

## Pipeline Construction

**Gas-Pipeline Projects Mount.** *Oil Gas J. 59,* 95 (1961) Sept. 4.

Record total of natural gas transmission facilities was authorized by the Federal Power Commission in the 1961 fiscal year, which ended June 30. The value: $852,168,000. The 1961 facilities include about 6000 miles of pipeline and addition of 330,000 hp in compressor capacity. This will add about 4 billion CF/day to delivery capacity of the nation's transmission systems. Major projects are planned by: Pacific Gas Transmission Co. (see article, p. 212); Natural Gas Pipeline Co.; Colorado Interstate Gas Co.; and El Paso Natural Gas Co.

## Pipeline Operations

**Coal by Pipeline.** A. N. Sharp. *Coke and Gas 23,* 336 (1961) Aug. (3 pp.)

Pipelines offer a promise of cheaper bulk transportation of coal than do existing methods, but only for small-diameter industrial grades. The two essentials for an economic coal pipeline would be high load factor, as in the case of a common line from a group of mines to a large industrial coal-using area, and the development of a simple, cheap method of dewatering the coal after transmission. Prospects of using coal pipelines in Great Britain are discussed.

## Safety

**Flammable Materials: A Lecture Demonstration.** M. G. Zabetakis and H. H. Engel. *U. S. Bur Mines Inf. Circ. 8005.* (Washington, D. C.; U. S. Govt. Print. Off., 1961; 17 pp.)

Publication contains highlights of lecture and demonstration presented by the Bureau to the U. S. Coast Guard's Dangerous Cargo Handling School. Topics covered include: fire and explosion hazards of flammable liquids and solids, oxidizing materials, corrosive liquids, and compressed gases.

**How to Operate a Flare System Safely.** W. C. Bluhm. *Oil Gas J. 59,* 73 (1961) Aug. 28 (6 pp.)

Five most frequent causes of accidents involving flare systems which are likely to cause serious damage are: internal explosions; liquid carryover from flare stacks; low-temperature failure; system obstructions; and faulty maintenance procedures. All of these have one common denominator: the entry of materials that the system is not built to accommodate. These may be air, steam, heavy oil, corrosive materials, low-boiling hydrocarbons, or excess liquid. Article reviews these hazards to see what can be done to minimize them through proper design and operating procedure.

**Safe Tank Entry.** *Ind. Eng. Chem. 53,* 69A (1961) Sept. (3 pp.)

Chemical plant personnel must often enter enclosed spaces to clean, inspect, repair, or perform other duties associated with either the equipment or the process. Several types of enclosed spaces, or tanks, are potentially hazardous. Although the character and degree of specific hazards and combinations of hazards will usually be different for the various cases, there are certain fundamental precautions and procedures which should be observed for positive accident prevention. Article contains information from the new Safety Guide (SG-10) just published by the Manufacturing Chemists' Association as a pamphlet, "Entering Tanks and Other Enclosed Spaces."

**Utilities Cooperate to Safeguard Underground Facilities.** J. J. Burns. *Gas 37,* 61 (1961) Sept. (3 pp.)

Expanded construction programs in the Chicago area and widespread use of excavating machinery caused an alarming increase in damage to underground facilities owned by utilities. Analysis of accident records showed that in many instances, the construction activities of one utility company were damaging underground gas pipes or cables of another. Utility companies decided that if they cooperated in safeguarding each other's underground facilities, much of the damage could be prevented. Cooperation has taken the form of intermittent negotiations over a period of several years. The negotiations have developed general principles for the exchange of information between the three utilities (gas, electric and telephone) to safeguard each other's underground facilities. The general principles are outlined in article.

### Synthetic Rubber

**Synthetic Rubber—Petrochemical Giant—and Still Growing.** *Oil Gas J. 59,* 176 (1961) Sept. 4 (3 pp.)

Synthetic rubber industry is headed toward continued growth and expansion in the years ahead. In 1960, two new polymers, cis-polyisoprene (Shell Chemical Co.) and cis-4 polybutadiene (Phillips Chemical Co.) achieved commercial production. Production of a third polymer, Diene polybutadiene (Firestone Tire and Rubber Co.) was started in March 1961. Other new developments and continued modifications of existing synthetics promise future change and improvement.

## 2. ENERGY SUPPLY AND ECONOMICS

### Competitive Fuels

**Basic Error in the Beltsville Tests Exposed.** C. C. Turner. *LP-Gas 21,* 19 (1961) Sept. (3 pp.)

Author contends that a serious error, made in conducting the Beltsville tests of LPG appliances, invalidates the results. He believes that the pressure test was not conducted at the appliance, but at some point halfway between the gas supply and the appliance. Under the conditions specified in U. S. Dept. of Agriculture Technical Bulletin No. 1073 and in a letter written to the author by a Department of Agriculture physicist, it would have been absolutely impossible for any LPG appliance to have operated at the gas pressure for which it was designed. Author includes letter to prove his point.

**Natural Gas and the Competitive Fuel Market.** F. J. Quinn. *J. Petrol. Tech. 13,* 727 (1961) Aug. (6 pp.); **Discussion.** I. A. Given. *Ibid.,* 731 (1961) Aug.

Natural Gas Act of 1938, which put interstate pipelines under the jurisdiction of the Federal Power Commission, did not place a protective competitive shield around such companies, nor does any provision of the act guarantee them a profit. Natural gas pipelines and gas distributing companies must compete with the coal, oil and electric industries. Oil men contend that gas prices have been held to an artificially low level by regulation. The electric industry is moving into the space-heating market, which pleases the coal people. The coal industry is attempting to monopolize the industrial and electric generating market through government intervention. This is being done under the guise of concern for the national welfare through advocation of a "National Fuels Policy" purporting to further the cause of fuel conservation. Author reviews situation and its implications.

### Electricity

**What's Ahead for Electric Heat.** *Nat. Petrol. News 53,* 92 (1961) Aug.

Electric heat is expected to go into 4,668,000 homes, commercial establishments, and industrial plants by the end of the 1960s—a 45% gain in the decade. Breakdown looks like this: 4,280,000 homes—a 465% gain over the 920,000 homes served by electric heat last year. (By 1969, total of electrically heated homes will be 5.2 million); 360,000 commercial establishments—a 400% gain over the 90,000 of last year. (By 1969, electric heat will serve 450,000 commercial establishments); 28,000 industrial plants—a 233% gain over the 12,000 plants served last year. (By 1969, industrial plants with electric heat will hit 40,000).

**When, How, and Why to Consider the Use of Electric Heating.** *Heating, Piping and Air Conditioning 33,* 153 (1961) Sept. (12 pp.)

While electrical energy costs in most localities are higher than those for other energy sources, total owning

and operating costs of the electric heating system are sometimes competitive and may be less than those for other systems. In addition, the convenience of using direct electric heating in certain applications, for example for terminal reheat in spaces with variable occupancy, may outweigh operating cost considerations. The changing relationship of basic energy costs, increasing internal loads, and a wide variety of electric heating equipment have made direct electric heating another available method. Wisely used, electric heating can serve economically and satisfactorily in many applications, according to survey.

## Energy Sources

**Leaders Lock Horns on Key Energy Issues.** D. E. Lambert. *World Oil 153,* 53 (1961) Aug. 1 (4 pp.)

Twenty oil, gas and coal leaders, government officials and educators picked a common ground to air conflicts and mutual problems concerning government relations with the fuels industries—the Second Annual Energy Institute held at American University in Washington, D. C. Perhaps the most important area of agreement is that oil, gas and coal are entering a new era. Article presents main ideas expressed on four problem areas: 1) Will Oil Take Its Cue from Coal on Depletion? 2) Trade Policies Curb Industry Development; 3) Natural Gas Cuts Deep into Coal's Profits; and 4) Federal Data Costs Solution Hits a Snag.

## Fuel Cells

**Fuel Cell Literature.** R. Clay. *Gas 37,* 71 (1961) Aug. (4 pp.)

Three book reviews and an abstract of an A.G.A. paper, the latter authored by *Institute of Gas Technology* staff members, present a broad look at fuel cells and give varying views of the role of gas.

*(The following 12 abstracts are based on papers delivered during the Symposium on Fuel Cells, ACS Meeting, Chicago, Sept. 3-8, 1961. For details on publication of papers, write the Secretary, Committee of Editors, ACS Publications, 1155 Sixteenth Street, N. W. Washington 6, D. C.)*

**Advances in Fuel Cell Technology.** A. M. Moos.

Introductory lecture cites advances in fuel cell technology made during the two-year period since the last symposium. Author predicts extensive growth in this field because of the vast applications yet to be developed.

**High-Temperature Methane Fuel Cells.** E. B. Shultz, Jr., K. S. Vorres, L. G. Marianowski and H. R. Linden.

Relative merits of two methods of methane utilization are discussed: reaction in the presence of steam in high-temperature fuel cells, and external conversion to hydrogen, for use in hydrox cells with ion exchange, acid or caustic electrolytes. Current and power densities of practical interest were sustained at low flow rates with methane-steam feeds in fuel cell tests with molten carbonates, sintered nickel and silver electrodes, and improved sealing methods. Catalytic activity tests showed that the nickel anodes catalyzed methane reforming, comparable to commercial practice with supported catalysts. Without steam, carbon formation occurred. Carbonates have inherent drawbacks. To avoid problems of corrosion, electrolyte decomposition and retention, and to eliminate need for $CO_2$ addition to the air, solid ionic oxides are being investigated as electrolytes. The mechanism of oxygen transfer in oxide cells is discussed.

**An Outline of the Economics of a Domestic Fuel Cell System.** C. G. von Fredersdorff.

General relation was developed for a residential fuel cell system using natural gas, involving capital and operating costs, load factors, efficiencies, and payout time, where savings accrue because of the higher cost of purchased electricity. By fixing payout time and operating cost parameters, the range of acceptable investment cost can be defined. Domestic electric appliance load factors may range from 15 to 20%, but the fuel cell load factor can be much higher by interposing lead-acid storage batteries. This permits a considerable reduction in power pack size, as well as compensation for the electrical loss and added cost of the storage system.

**High Drain Double Skeleton Catalyst ("DSK") Diffusion Electrodes for Oxygen.** H. M. Dittmann, E. W. Justi and A. W. Winsel.

Authors describe development of a DSK electrode for $O_2$. The catalyst is a special very brittle Raney Ag alloy. Process used in developing the electrode is described. The electrodes thus produced give $> 3.7$ electrons per mole $O_2$, compared with 2 electrons of the Berl process and 4 electrons of the ideal process. The electrode weight is 0.94 g/cm$^2$.

**Recent Developments in High Temperature Cell Research in the Netherlands.** G. H. J. Broers and M. Schenke.

Maintenance of the essentially necessary gas tightness in high-temperature cells can be greatly and permanently improved by the use of a paste-like electrolyte, composed of an inert (nonrefractory) powder matrix (MgO) and molten carbonates. Experiments with tubular and block shaped cells are discussed, including $CO_2$ transfer through the electrolyte and the electrode behavior.

**A Preliminary Appraisal of the Ammonia Fuel Cell.** R. A. Wynveen.

Preliminary analysis is made of the ammonia fuel cell. The main emphasis, however, is placed on the potential of ammonia as a fuel cell fuel. The characteristics of ammonia are discussed from theoretical and practical points of view. Specifically, the stoichiometric analysis of the exit fuel exhaust, half-cell reactions, and proposed mechanism are discussed. The economic feasibility and physical characteristics, such as ease of storage and handling, are presented.

**Ion Exchange Membranes in Hydrogen-Oxygen Fuel Cells.** R. M. Lurie and C. Berger.

The hydrogen-oxygen ion exchange membrane fuel cell has been investigated. The limitation on performance appears to come from two sources. First, dehydration of the membrane occurs due to the air coming into the oxygen electrode, resulting in excess evaporation of

water. Second, concentration gradients may be established in the aqueous phase in the membrane or in the thin aqueous layer between the catalysts and the membrane. These phenomena can result in very high resistance. Data on membranes designed to overcome these two areas of difficulty are presented. These data are obtained in $H_2$-$O_2$ fuel cells as well as in membrane resistance tests in solutions of varying normality.

**Polarization at Diffusion Electrodes.** L. G. Austin.

Analysis of polarization at a diffusion electrode shows that four zones of polarization versus current exist. The first zone occurs at low currents where the electrode is close to reversible. The second zone occurs at higher currents, and is characterized by the normal Tafel equation. At higher currents, a third zone is entered where concentration polarization occurs within the pores of the electrode; the voltage-current relation follows a Tafel equation but with double the voltage drop per logarithmic increment of current. The final zone is that where concentration polarization outside of the electrode is the current limiting factor. In practice, the zones rarely occur discretely, and a more general equation is presented.

**Theory of Polarization of Porous Gaseous-Diffusion Electrodes.** H. B. Urbach.

Theoretical model of a porous electrode is presented which takes into account the internal resistance of the electrolyte within the electrode as well as concentration and activation polarizations. Equations for the decay of polarization with time have been derived for this model and the resulting equations have been solved on an analog computer.

**Potential Distribution and Internal Resistance in Electrochemical Matrix Cells with Discontinuous Contacts.** M. Eisenberg and L. Fick.

In many types of electrochemical fuel cells a solid matrix type of electrolyte is employed. The electrodes contacting such electrolytes must have openings to permit access of the anodic and cathodic reactants. On the other hand, the use of such discontinuous contact electrodes may under some circumstances result in a sizable increase of the effective cell resistance, over that which would exist with solid continuous connecting electrodes. Four mathematical cases have been solved, including square contact, square hole, circular contact and circular hole electrodes. The Laplace equation is solved to obtain the primary potential distribution. From this, the ratio of effective cell resistance to the resistance of identical cells with solid continuous contact electrodes is calculated.

**The Electrochemical Oxidation of Hydrocarbons in a Fuel Cell.** C. E. Heath and C. H. Worsham.

Study was conducted to determine the nature and extent of ethane oxidation in a Bacon-type fuel cell at 250°C and 28 atmospheres pressure. Both electrical and chemical product balances demonstrated essentially complete oxidation to $CO_2$. When the cell was operated at 6.9 amp/ft², 97% of the carbon reacted to $CO_2$, the remainder to formic acid. In close agreement with the postulated reaction at the fuel electrode, $C_2H_6 + 14OH^- \rightarrow 2CO_2 + 10H_2O + 14e$, an electron yield of 13.9 was obtained. This work has shown that the electrochemical oxidation of ethane in fuel cell is essentially stoichiometric.

**Fuel Cell Intermediates and Products.** M. J. Schlatter.

Relative fuel cell reactivities of many substances were determined at 25-80°C on platinized porous carbon anodes. Intermediates and products formed at the anode were no more reactive than the same substances tested separately. In base, secondary alcohols gave electrochemically unreactive ketones and their polymerization products; primary alcohols gave stable carboxylates via reactive aldehydes. Formate is an exception; it can be slowly oxidized to carbonate. The effects of fuel cell reactant structure on reactivity and implications for reaction mechanisms are discussed.

## Magnetohydrodynamics

**Studies on Magneto-Hydrodynamic Waves and Other Anistropic Wave Motion.** M. J. Lighthill. *Phil. Trans. Roy. Soc. Land (A) 252,* 397 (1960) Mar. (36 pp.) [From *Appl. Mech. Rev. 14,* 645 (1961) Aug. (2 pp.)]

Equations of magnetohydrodynamics of a compressible, perfectly conducting fluid, neglecting viscosity and heat conduction, have been linearized by perturbing a constant magnetic field using the acoustic approximation, and the equations for the propagation of X-component of vorticity, dilation and X-component of strain-rate are derived. These are partial differential equations with constant coefficients. The waves due to a point source of finite and infinitesimal extent are considered, and attention is primarily focused on sources of fixed frequency. The asymptotic solutions are obtained satisfying the radiation condition, which represents waves going out from the source. S. D. Nigam

**The Effect of a Very Strong Magnetic Cross-Field on Steady Motion Through a Slightly Conducting Fluid.** G. S. S. Ludford. *J. Fluid Mech. 10,* 141 (1961) Feb. (15 pp.) [From *Appl. Mech. Rev. 14,* 646 (1961) Aug.]

Paper studies theory of conducting fluid flow past body in two dimensions, in the reasonably realistic limit of high Hartmann number (inviscid), low magnetic Reynolds number (uniform field imposed perpendicular to free stream, unperturbed by fluid motion) and low velocity or low density, etc., such that inertia forces are negligible in comparison with magnetic forces. In the limit all quantities become invariant in the field direction and the solution is not unique. Author resolves ambiguity by reintroducing inertia and studying the behavior of the solution as inertia tends to zero.
J. A. Shercliff

## Petroleum

**Midyear Report.** *Oil Gas J. 59,* 125 (1961) July 31 (32 pp.)

Annual midyear report indicates that the first half of 1961 was good—perhaps too good. According to survey

findings, all operations will need a firm hand if a ruinous glut is to be avoided. Possible trouble spots: domestic crude output was too high in the first six months, and needs cutback. Current big inventories of LPG could touch off adverse price repercussions. Excessive buildup of product stocks might mean industry will be out as much as $20 million for storage alone this year. Pipeline construction will pick up in last half. Gains in liquid lines will offset gasline lag. Gas prices are low. In every market where gas and oil compete, gas is taking the business away from oil.

**Operating Costs of Typical Refineries.** W. L. Nelson. *Oil Gas J. 59,* 148 (1961) Sept. 11 (3 pp.)

Estimations of average operating costs of U. S. refineries are useful, says author, but they fail to introduce two important variables: 1) size, and 2) type of management. Accordingly, he compares the cost of operating a complete (average) 150,000 bbl/day refinery and a fuel-type 20,000 bbl/day refinery located in the Mid-Continent area.

**16th Annual International Outlook Issue.** *World Oil 153,* (1961) Aug. 15 (entire issue)

Review issue contains data on world trends, and petroleum demand and supply, production, reserves, drilling and geophysical activity. The world picture is reviewed by these geographic divisions: North America; Central America and West Indies; South America; Europe; Africa; Asia, Middle East; Asia, Far East; and Oceania.

### Tar Sands

**Are the Tar Sands Now Competitive?** *Oil Gas J. 59,* 79 (1961) Aug. 14 (3 pp.)

Secret which will unlock the world's greatest reserve of hydrocarbons—the 300 billion barrels in the Athabasca tar sands of Alberta—has apparently been found. Four-company combine reportedly has broken the technology barrier with a process to turn tar sand into crude economically. A 3000-bbl/day pilot plant, operated by Cities Service Athabasca, Inc., Richfield Oil Corp., Imperial Oil, Ltd., and Royalite Oil Co., has proved successful. Next step is construction of a commercial plant to produce 100,000 bbl/day of crude oil.

### Thermoelectricity

**Temperature Control with Thermoelectrics.** W. R. Stubstad. *Control Eng. 8,* 178 (1961) Sept. (2 pp.)

Thermoelectric device development has reached the point where specific engineering applications of Peltier heating and cooling are practical. Typical applications are spot cooling of critical electronic components and air conditioning of special enclosures. Beyond these, general purpose commercial and consumer applications will be feasible in the mid 1960's. Article examines characteristic current units of use to control engineers, samples commercial equipment, and gages the potention of thermoelectrics.

## 3. NATURAL GAS AND PETROLEUM PRODUCTION

### Drilling

**A New Method for Calculating Rate of Return of Oil and Gas Drilling Investment.** H. H. Hill. *Oil Gas J. 59,* 86 (1961) Aug. 28 (7 pp.)

Calculation of rate return for income from oil and gas properties is complicated by the fact that such income seldom remains constant over the entire producing life of the properties. A quick and efficient method of evaluating the economics of individual drilling projects is becoming more important in view of continued rising costs. The discounted cash flow, or rate-of-return method of evaluation, is considered to be efficient. Study suggests use of present-worth factors in conjunction with production-decline-curve formulas. Rate of return may then be calculated for 1) constant income rate, 2) income rate declining exponentially, and 3) any combination of 1) and 2). The compounding period may be annual, monthly or continuous.

**Gas Drilling Reduces Costs in Mississippi.** J. N. Howell. *World Oil 153,* 107 (1961) Sept. (7 pp.)

Shell Oil Co. recently saved $100,000 using gas as the circulating medium in the Jarrett et al Unit 1 Siloam field, Clay County, Miss. Use of gas resulted in a saving of 70.5 drilling days, a reduction of 93 bits, and a saving of $10,040 in the circulating medium. Author describes general procedure in article, and attaches two appendices which detail rig equipment and safety precautions.

### Drilling Muds

**How You Can Get Smaller Volumes from Standard Mud Pumps.** W. E. Liljestrand. *Oil Gas J. 59,* 82 (1961) Aug. 21 (9 pp.)

Slowing the pump and changing liners are best means of obtaining smaller volumes; if volume must be reduced even further, one or more valves must be removed. Author gives an analysis of which valves should be changed for various reductions in flow.

**New Inverted Emulsion Makes Good Drilling and Completion Fluid.** T. E. Watkins. *Oil Gas J. 59,* 176 (1961) July 31 (4 pp.)

Article is an abridged version of a paper titled, "New Formulations for Inverted-Emulsion Completion and Drilling Fluids," given by the author at the 1961 spring meeting of API Division of Production's Mid-Continent District, Tulsa. Gist of article: what appears to be a real breakthrough in oil muds can be used to drill, complete or workover wells. It is stable, simple, inexpensive, and easy to control. A wide range of water contents can be used, and the oil mud keeps hole to gage in shale formations.

### Exploration

**Arkoma Basin . . . Full of Gas—and Headaches—for Drillers.** W. B. Bleakley. *Oil Gas J. 59,* 182 (1961) Sept. 4 (3 pp.)

Because of the varied nature of the drilling problems in the Arkoma basin, practically every conceivable way of drilling wells has been tried so far. Conventional rotary, with gas and with mud, cable tools, and the hammer drill have all been used. At present, wells are drilled through the Booch and the Hartshorne with a 9-in. hammer drill below 175 ft of conductor pipe, using gas as the drilling fluid. Gas is taken from wells already completed in the field. Mist drilling will be used if small amounts of water are encountered. Drilling continues to a point about 100 ft into the Atoka shale.

**Deeper Gas Pays Spur Arkoma Basin Activity.** J. A. Kornfeld. *World Oil 153,* 94 (1961) Aug. 1

Sprawling over 13 counties, the Arkoma Basin of southeastern Oklahoma and western Arkansas is the locale of one of the most active gas plays in the nation. A survey of current drilling activity reveals that 46 rotary drilling rigs were in operation on July 11 throughout the Arkoma Basin. Exploratory drilling is about evenly divided between the two states, with eight wildcats listed for Oklahoma and seven for Arkansas. There are 31 development wells now drilling in semiproven discoveries, most of which were found in 1960. Adding to the interest is assurance by major operating companies that a big-inch natural gasline will be laid in the basin during the coming year.

**Fairway: Biggest New Field in Years.** R. J. Enright. *Oil Gas J. 59,* 75 (1961) Sept. 11 (3 pp.)

Ultimate recoverable reserves in East Texas' Fairway field are figured at a possible 400 million barrels, making it a relative of Van and Hawkins fields (also in E. Texas). A little more than a year old, Fairway is the biggest domestic discovery since Aneth. By September, Fairway had chalked up an even 50 completions. Nine more holes were going down and eight others were ready to start. By the end of the year, there may be 80 completions in the sprawling Henderson-Anderson counties pool—which still has not been defined.

**Grimes Area Gets Its Fourth Field.** C. J. Lawrence. *Oil Gas J. 59,* 139 (1961) Aug. 28.

Grimes gas area in Colusa and Sutter counties, California, has come up with another gasfield, the fourth since January 1960. Los Angeles independent completed the discovery well in East Grimes field early in August. It is a dual-zone completion in the F zone Upper Cretaceous sands, and represents the twenty-third gas completion made in this area since Grimes was discovered in January of last year. The area has been one of the hot spots in the Sacramento Valley gas play and is expected to see much more drilling. All wells are shut in, awaiting a pipeline outlet.

**Mathematical Probability Is an Oil-Search Tool.** J. P. Dowds. *World Oil 153,* 99 (1961) Sept. (6 pp.)

Contrary to the belief held by many geologists, there are a number of mathematical concepts that can be helpful in solving exploration problems. An independent producer has based his development and growth on reducing geological and reservoir data to digital terms, and processing it in electronic computers to evaluate subsurface prospects. The firm has 5200 acres of productive leases after three years of operations and an 82% drilling success ratio, despite a high proportion of wildcats. Entropy studies developed in article are ideas that have been borrowed from information theory and statistical mechanics.

**Upgrade Lower Minnelusa Plays with Lithofacies Maps.** W. N. Zakis. *World Oil 153,* 67 (1961) Aug. 1 (6 pp.)

Dual-purpose article evaluates oil and gas prospects of the lower Minnelusa (Pennsylvanian) formation in Wyoming, Nebraska, and South Dakota. It also shows the effective way in which prospective trends are identified through regional mapping of rock types showing quantities of sediments deposited, origin, environments, possible reservoir and petroleum source rocks, plus their relationships to one another.

**Permian Reefing on the Chadron Arch.** C. R. Barr and A. M. Bieber. *Oil Gas J. 59,* 212 (1961) Sept. 4 (4 pp.)

Discovery of oil in the basal Pennsylvanian sand at Sleepy Hollow field, Neb., has renewed interest in the Chadron arch. Arch is a link in the present uplift trend that extends from the Central Kansas uplift, through Nebraska to the Black Hills of South Dakota. Indications that Permian reefing may be present on the west flank of the Chadron arch include: 1) basin sediments typical of a restricted arid basin environment; 2) rapid change from salt to anhydrite to shelf carbonates to lagoonal evaporites and carbonates; 3) lagoonal-type facies on the crest; 4) numerous algae and oolites in the downdip carbonates; and 5) presence of other Permian reefs in almost the same latitude.

## Logging

**Induced Nuclear Reaction Logging.** W. A. Hoyer, *J. Petrol. Tech. 13,* 797 (1961) Aug. (6 pp.)

Pulsed high-energy neutron-induced spectral logging tool has been built and field tested. The reaction of deuterium on tritium is used to generate pulses of 14-Mev neutrons. By detecting only the prompt gamma rays produced by neutron inelastic reactions in the formation, the presence and relative abundance of carbon, oxygen, calcium, silicon and other important elements may be ascertained from a gamma-ray spectrum. Gamma-ray spectra obtained in a shallow test well and in experimental field use show that it is possible to identify formations and their contained fluids.

**Some Phenomena Pertinent to Velocity Logging.** M. R. J. Wyllie, G. H. F. Gardner, and A. R. Gregory. *J. Petrol. Tech, 13,* 629 (1961) July (8 pp.)

Main experimental facts relative to understanding and interpreting the continuous velocity log are reviewed. Experience shows that the velocity through liquid-saturated rocks primarily depends on porosity, and that the "time-average" formula can be relied on to give the dependence within about 5%. An exception occurs in the case of shallow unconsolidated sands. Data are given for the dilatational and shear velocities through dry rocks under a high confining stress. It is argued that a correction made for pressure increase or porosity

reduction with depth in the interpretation of a velocity log is unwarranted because of the many uncertain parameters involved. The application of Biot's theory is discussed, and illustrated with a numerical example.

**The Use of Differential Sonic-Resistivity Plots to Find Movable Oil in Permian Formations.** R. H. Lindley. *J. Petrol. Tech. 13,* 749 (1961) Aug. (7 pp.)

In recent years, plotting of sonic transit time vs resistivity recorded by a deep investigation device has become widely used to interpret electrical logs run in wells drilled with salt mud. Paper reviews the reasons why this method is valuable. It also discusses pitfalls in the method, which may be overlooked because of its convenience. A possible source of error emphasized is the common assumption that all zones analyzed are affected in the same degree by mud-filtrate invasion. The use of a second sonic-resistivity plot, this time with a shallow investigation resistivity device, is presented.

## Offshore Operations

**Industry Views Oregon's Offshore Progress.** *Drilling 22,* 56 (1961) Aug.

West Coast operators have shown interest in offshore prospects in Oregon since Shell Oil Co. offered to lease all the submerged land owned by the State in October 1960. Offer necessitated introduction of a bill in the state legislature for leasing of tide and submerged lands. Salient features of proposed legislation law are listed. Oil company representatives feel it is workable and that it should provide incentive for exploration.

## Reservoir Engineering

**A Simple Method for Correcting Spot Pressure Readings.** F. Brons and W. C. Miller. *J. Petrol. Tech. 13,* 803 (1961) Aug. (3 pp.)

Pressure information for use in material-balance calculations is obtained, where possible, from pressure buildup surveys in shutin wells. Using proper extrapolation methods, static pressures are obtained which, by averaging, give the field static pressure. Often, particularly in fields with a large number of wells, only spot pressure readings are available. A graphical method is presented which enables the determination of the corrections which must be applied to the spot readings to give an estimate of the static pressure.

**Analysis of Gas-Cap or Dissolved-Gas Drive Reservoirs.** J. L. Stone and A. O. Garder, Jr. *J. Soc. Petrol. Eng. 1,* 92 (1961) June (13 pp.)

Numerical method of solving the partial differential equations which describe the one-dimensional displacement of oil by gas has been presented. Possible extension of the method to treat multidimensional flow is discussed, and the limitations of this extension are indicated. The influence of relative permeability and the force of gravity in the direction of flow upon the displacement are considered.

**An Evaluation of the Significance of Permeability Measurements.** J. E. Warren, F. F. Skiba and H. S. Price. *J. Petrol. Tech. 13,* 739 (1961) Aug. (6 pp.)

Technique for comparing core analysis permeabilities to those determined from pressure buildup tests has been developed. This comparison has been used to obtain a qualitative indication of the spatial permeability distribution within the producing formation. Data from 14 wells, equally divided between the Bromide sands and the McKnight dolomite, have been analyzed; results have indicated that the permeabilities in those particular reservoirs are randomly arranged so that they appear to be homogeneously heterogeneous. It has been emphasized that more accurate core data, improved pressure buildup testing and independent determinations of anisotropy are needed before a more quantitative description of the reservoir is feasible.

**Determining Areal Permeability Distribution by Calculations.** W. D. Kruger. *J. Petrol. Tech. 13,* 691 (1961) July (6 pp.)

Calculation procedure is presented for determining the areal permeability distribution in the reservoir. Use of the procedure allows verification of the basic reservoir data through the matching of past reservoir conditions, thereby providing proper data for reliable predictions of future operations. The calculation procedure is a numerical technique based on a mathematical model of the reservoir, and is designed for solution by means of an electronic digital computer. Results from field application of this procedure are presented. Permeability distributions from measured data are compared to those calculated to indicate the need for the analysis. Comparisons of field measured and calculated pressure distributions are given to establish the validity of the calculation procedure.

## Secondary Recovery

**Effect of Bank Size on Oil Recovery in the High-Pressure Gas-Driven LPG-Bank Process.** J. W. Lacey, J. E. Faris and F. H. Brinkman. *J. Petrol. Tech. 13,* 806 (1961) Aug. (7 pp.); **Discussions.** C. A. Connally, *Ibid.,* 812 (1961) Aug. (2 pp.); A. L. Benham, W. B. Gogarty and F. H. Poettmann, *Ibid.,* 813 (1961) Aug. (2 pp); F. F. Craig, Jr. and R. C. Koeller, *Ibid.,* 814 (1961) Aug.

Paper presents an analysis of the high-pressure gas-driven LPG-slug process, based on fluid flow tests in areal models. Two types of tests were conducted: 1) in low-pressure models which permitted observation of fluid movement; and 2) in high-pressure models using methane, propane and a light refined oil saturated with methane at room temperature and 1550 psig; under the first conditions, the phase diagram for the fluids used is similar to those for many of the field systems where the process is considered for use. A method for using these laboratory data to calculate field performance of the process is outlined.

**The Linear Displacement of Oil from Porous Media by Enriched Gas.** H. J. Welge, E. F. Johnson, S. P. Ewing, Jr. and F. H. Brinkman. *J. Petrol. Tech. 13,* 787 (1961) Aug. (10 pp.)

Paper presents a method for predicting the manner in which oil will be displaced from a porous body by

enriched gas. The calculations apply to a gas rich enough to give a partial miscible displacement. The method—a three-component two-phase analysis—takes into account condensation of some of the intermediate hydrocarbons from the injected gas into the oil, as well as enhanced volatility of heavier hydrocarbons at elevated pressures and temperatures. The condensation swells the oil and decreases its viscosity, thus aiding in its recovery. The calculations have been extended to apply to actual crude oil-natural gas systems by arranging the components into three groups according to their volatility.

### Well Practice

**Small Diameter Well Completions. Part 1. Economics and Application.** R. W. Scott and J. F. Earl. *World Oil 153,* 57 (1961) Aug. 1 (9 pp.)

Small-diameter well completions have been made in practically all oil provinces in the United States and Canada. Because of the mechanical success of the technique and its economic benefits, it is anticipated that the procedure will grow in acceptance. Small cased wells have been successfully completed in almost all areas of oil and gas production operations, and trends indicate continued expansion of the method. This first of a comprehensive series of articles, which will cover all phases of the technique, discusses terminology, economics, advantages, limitations, and application of slim hole drilling techniques to small cased wells.

**Small Diameter Well Completions. Part 2. Casing Programs and Primary Cementing Equipment.** R. W. Scott. *World Oil 153,* 79 (1961) Sept. (11 pp.)

Article is concerned with that section of Engineering Practices Report No. 4 which presents successful casing programs for small-diameter wells. In some cases, programs were designed for requirements of a specific area, and it is not intended that each type discussed be considered applicable to all areas of operation. Casings, single- and multiple-completions, cementing, fittings and tools are covered.

## 4. GAS CONDITIONING AND LPG RECOVERY

### Carbon Dioxide Removal

**Method of Separating Carbon Dioxide from Gaseous Mixtures.** G. Giammarco (assigned to S.p.A. Vetrocoke) U. S. 2,993,750 (1961) July 25.

Method of separating carbon dioxide in amounts over 2% is claimed. The raw gas is contacted with an alkaline solution which carries an absorption promoter (protides or amino acids) to suppress corrosion of the contactor metals and decomposition of the solution. The fouled solution is heated, degasified to recover $CO_2$, blown with air, and recycled to the purifier.

**Separation of Carbon Dioxide from Ammonia.** S. Vasan and L. H. Cook. U. S. 2,992,703 (1961) July 18.

Method of removing small amounts of carbon dioxide from ammonia gas is claimed. This comprises passing the gas through a bed of zeolite molecular sieve of at least 4 Angstrom unit aperture, where $CO_2$ adsorption is preferentially enhanced by ammonia. After the $CO_2$ breakthrough point is reached, the bed is regenerated by indirect heating while being purged with purified $NH_3$. Alternating beds, and dehydration means may be used.

### Carbonyl Sulfide

**Studies Show Carbonyl Sulfide Problem.** R. L. Pearce, J. L. Arnold and C. K. Hall. *Petrol. Refiner 40,* 121 (1961) Aug. (6 pp.)

Processing of gases which contain carbonyl sulfide imposes an additional requirement upon an acid gas absorbent. In the case of a monoethanolamine system, the losses of amine will fall in the range of 10-20% reaction between carbonyl sulfide and monoethanolamine. These losses may be reduced by maintaining an excess of free caustic in a sidestream still. Diethanolamine scrubbing will give a sales gas with little or no carbonyl sulfide without loss of base strength. However, the additional capital investment in plant facilities is a major consideration and should be evaluated with each plant situation, say authors.

### Dehydration

**Equilibrium Ratios of Water in the Water-Triethylene Glycol-Natural Gas System.** F. R. Scauzillo. *J. Petrol. Tech. 13,* 697 (1961) July (6 pp.)

Author develops equilibrium relationship between water in the dried natural gas and water in aqueous triethylene glycol (TEG) solutions. He demonstrates use of the relationship in designing the TEG-type dehydration unit.

### Dust Removal

**Applications of Wet Scrubbers in Industrial Gas Cleaning.** G. T. Nicklin. *Air Eng. 3,* 37 (1961) July (5 pp.)

Article summarizes performance characteristics of scrubbers in low-, intermediate- and high-pressure drop categories with emphasis on the impingement type. Performance tests on the Doyle type are discussed in detail.

**Successful Cleaning of Open-Hearth Exhaust Gas with a High-Energy Venturi Scrubber.** C. A. Bishop, W. W. Campbell, D. L. Hunter and M. W. Lightner. *Ind. Heating 28,* 1516 (1961) Aug. (3 pp.)

Because of improvements in both the design and the operation of the Pease-Anthony venturi-scrubber system, scrubbers now appear to be more favorable than precipitators for cleaning open hearth exhaust gas. This is especially true for shops where waste-heat boilers would be required. An evaluation of the performance of a venturi-scrubber system installed on a 225-ton open hearth furnace is given.

### Hydrocarbon Recovery

**New Hydrocarbon Extraction Unit Designed for Small, Rich Gas Streams.** J. L. Horton. *World Oil 153,* 93 (1961) Sept. (4 pp.)

Skid-mounted, packaged low-temperature separation equipment uses compression cycle, and can be applied

to leases producing as little as 500 MCF/day. Mechanical compression units also can be used: to supplement low-temperature separation systems, using pressure drop as a source of refrigeration; to economically strip and dehydrate gas from small reservoirs; and in conjunction with short-cycle hydrocarbon recovery units. Article describes operation and applications of unit.

### Hydrogen Sulfide Removal

**Equilibrium Pressures of Hydrogen Sulfide and Carbon Dioxide over Solutions of Potassium Carbonate.** J. S. Tosh, J. H. Field, H. E. Benson and R. B. Anderson. *U. S. Bur. Mines Rep. Invest. 5622.* (Washington, D. C.: U. S. Govt. Print. Off., 1961)

The Federal Bureau of Mines has investigated the equilibrium of the system potassium carbonate ($K_2CO_3$) potassium bicarbonate ($KHCO_3$) potassium bisulfide (KHS) carbon dioxide ($CO_2$) hydrogen sulfide ($H_2S$) water ($H_2O$). Partial pressures of hydrogen sulfide, carbon dioxide, and water vapor were measured at 70° to 130°C over solutions of 20-, 30- and 40%-equivalent potassium carbonate containing from 20 to 3000 grains of equivalent hydrogen sulfide per gallon of solution. This study was conducted to obtain equilibrium data for evaluating the feasibility of using solutions of hot potassium carbonate for removing hydrogen sulfide from gas mixtures. These data show that effective removal of both carbon dioxide and hydrogen sulfide can be achieved simultaneously with hot solutions of potassium carbonate.

**Hot Carbonate Solutions Do Not Degrade When Used for $H_2S$ Removal.** R. N. Tennyson. *Oil Gas. J. 59,* 109 (1961) Aug. 7 (3 pp.)

Even after prolonged use with a high ratio of $CO_2$ and $H_2S$ in the feed, hot potassium carbonate (Benfield) process will not deteriorate. High absorption efficiency and capacity were maintained through a 25-day run to reduce the acid gas content of a feedstream from 13.4% $H_2S$ and 4.6% $CO_2$ to 0.03% $H_2S$ and 0.07% $CO_2$. Process is described.

**New Process for Gas Purification.** J. Grindrod. *Gas Age 128,* 35 (1961) Aug. 17 (3 pp.)

Liquid purification process, known as the Stretford Process, offers economy, cleanliness and safety to a degree that suggests interesting potential for industrial applications. These include removal of $H_2S$ and production of sulfur from field gas, treatment of waste gases in refineries and tail gases sold to chemical industries, and recovery of sulfur in purification of synthesis gas.

**Process for Production of Sulphur from Sour Gas.** A. G. Eickmeyer. U. S. 2,994,588 (1961) Aug. 1.

Process for production of sulfur from sour gas containing hydrogen sulfide is claimed. It comprises circulating a stream of hot molten sulfur through a zone of contact with the sour gas, thereby absorbing the hydrogen sulfide. The gas is then passed through a reaction zone for contact and for reaction of hydrogen sulfide with sulfur dioxide. Elemental sulfur and water vapor are thereby produced.

**Trouble-Free Ethanolamine Gas-Treating Plants.** G. S. Leachman and G. C. Ellis. *Oil Gas J. 59,* 84 (1961) July 24 (5 pp.)

Ethanolamine solutions are widely used to remove hydrogen sulfide, carbon dioxide, and other acid gases from natural and refinery gases. Wide experience with both mono- and diethanolamine has shown that certain steps in the treating process frequently cause trouble. Solution foaming, loss in ability to accept the acid gases, and excessive equipment corrosion are only a few of the problems encountered. Many of these problems can be eliminated or alleviated if proper procedures and practices are taken during the startup period. And once the plants are on stream, certain checks and practices can do much toward assuring trouble-free operation. Start-up procedures which make for better operation, and some trouble-shooting hints which can keep a plant operating properly, are given.

### Sulfur Oxides Removal

**Process for Removing Sulfur Oxides from Gases.** K. Feustel and H. Stratman (assigned to Reinluft, G.m.b.H.) U. S. 2,992,065 (1961) July 11.

Process is claimed for removing sulfur dioxide and sulfur trioxide from hot gas streams This comprises contacting the hot gas with a carbonaceous adsorbent bed in an upper vessel at 150°-250°C. After saturation, the adsorbent is dropped to a lower vessel and regenerated by heating to 300°-600°C. The latter heating reduces any adsorbed $SO_3$ to $SO_2$, and purged adsorbent is screened free of agglomerates and returned to the top vessel for reuse.

## 5. NATURAL GAS TRANSMISSION

### Automation

**Automatic Control System for Gas Pipelines.** H. S. Izawa. *Gas Age 128,* 34 (1961) July 20 (2 pp.)

Automation road, says author, comprises three stages: remote control system for a compressor station, central dispatching station with a station control system similar to that in the first stage, and full automation via computers. Any scale and size of automatic system will give the advantages described in article. Method of automatic control systems is described.

**Automation in Gas Industry Operations. Part V. Columbia Gulf Transmission Co. Mountain Fuel Supply Co.** K. Kridner. *Gas 37,* 106 (1961) Sept. (7 pp.)

Author considers the practices of two transmission companies that use automatic control equipment. Columbia Gulf Transmission Co. has been recognized as the first natural gas pipeline designed for automation of its compressor station facilities. Company's promotion of advanced type prime movers through on-the-job application is furnishing industry technical and operating people with answers to many questions. Industry will watch closely as the jet gas turbine is put through its paces. Another application of automatic control equipment is that used by the Mountain Fuel Supply Co. in Wyoming. Installed in the early months of 1961, this system uses

solid-state components to supervise the opening and closing of block valves at nine locations over its 500-mile system. The company serves the three-state area of Colorado, Wyoming and Utah.

### Compressor Stations

**Gas Compressor Stations.** J. L. Joplin. *Pipe Line News 33,* 25 (1961) Aug. (5 pp.)

Since the semipermanent gas compressor is now an accepted tool of the oil industry, article is not concerned with its history, evolution or economics. It covers major points that may be used as a guide in writing specifications and in considering proposals from suppliers.

**Wanted—By El Paso Natural Gas Co. Analytical Tool to Evaluate and Improve Operations.** H. B. Martch, Jr. *Oil Gas J. 59,* 91 (1961) Aug. 21 (3 pp.)

Transient-flow equation, in conjunction with suitable mathematical representation of compressor stations, forms a mathematical model of a portion of the El Paso Natural Gas system. Computer solution enables investigation of the various effects resulting from changes in sales and operations.

### Metering

**Running-Type Meter Provers Are Fast, Flexible, Simple.** H. C. Bozeman. *Oil Gas J. 59,* 121 (1961) Aug. 7 (4 pp.); **Running-Basis Meter Proving.** *Pipeline Eng. 33,* 52 (1961) Aug. (4 pp.)

Running-type meter proving is a continuous-flow technique which accurately and repetitively displaces a known volume with a displacement-type device that is driven by the flow passing through the meter. Meter volume is compared with known prover section volume to find the meter factor. Wide acceptance of running-type meter proving will increase meter use for custody transfer because it is more efficient, costs less, and works faster than volumetric prover tanks.

### Pipe Linings

**Pipe Lining Apparatus.** W. E. Perkins and A. J. Perkins (assigned to Perkins Pipe Linings, Inc.) U. S. 2,988,042 (1961) June 13.

Pipe lining machine is claimed which is drawn through the pipe by cable toward a winch, while applying a coating to pipe wall by means of a centrifugal distributor head. The lining material is supplied by hose line from a tank at the winch. The improved features include a cable-speed signal which cooperates with a standard speed setting to control the speed of travel, and a mortar-flow signal which cooperates with a standard flow setting to provide a coating of uniform thickness.

### Pipeline Construction

**French Lay Pipe in 2,500 Feet of Water—For Practice!** D. M. Taylor. *Pipe Line Ind. 15,* 16 (1961) Aug. (9 pp.)

New technique can mean low-cost pipelining in deep water. The keys to the operation are a polystyrene buoy which will withstand deep water and high pressures, and a "breathing buoy" with a compressible bladder. A Mediterranean crossing is now possible.

**From Canada to California.** *Gas 37,* 105 (1961) Aug. (18 pp.)

The Alberta-to-San Francisco pipeline project is large—mainline miles will total 1368, with some 1243 miles composed of welded 36-in. diameter pipe. Its route in Canada totals 458 miles—125 miles of 30-in. and 226 miles of 36-in. pipe in Alberta, and 107 miles of 36-in. in British Columbia. The U. S. portion totals 910 miles, all of it 36-in. pipe. There will be 614 miles through Idaho, Washington and Oregon. Another 296 miles of mainline is going underground in California. The line thus traverses a variety of terrain and a considerable spread in climates. Article tells the construction story.

**How to Design Weight Coating with Computer.** C. H. Klohn. *Pipeline Eng. 33,* (1961) Sept. (2 pp.)

Author's company finds that the computer effectively builds engineering tables. For example, in the case of pipe laid in marshes and under bodies of water, one such table determines the thickness of concrete coating to apply to weight the pipe. Derivation of simple equation used to calculate the concrete thickness is shown. Weights and densities in an environment of fresh water for 20-in. pipe with varying wall thicknesses are shown in tabular form.

**Pipeline Padder Assembly.** O. G. Phillips (assigned to Thomas D. Copeland, Jr.) U. S. 2,987,891 (1961) June 13.

Continuous method of backfilling pipeline trenches is claimed which comprises placing a semicylindrical sheet arranged to roll along the positioned pipe to protect its coating from rocks. Earth backfill is poured onto the shield, which is continuously pulled along the pipe by a tractor. This causes the fill to be agitated and shaken down, with rocks falling only a small distance.

**Pipeline under the Forth.** R. O. Emmony. *Gas World 154,* (1961) Aug. 19 (4 pp.)

Scottish Gas Board designed and constructed a pipeline to carry gas from the Lurgi plant at Westfield in Fife, to local grid systems at Glasgow and Perth. One problem was crossing of the River Forth. At point selected for crossing, river is 2000 ft wide, and has considerable variation in water levels. Construction problems and their solutions are reviewed.

**The Crossing of Coldwater Creek.** W. H. Donnelly and E. V. McMullin. *Am. Gas. J. 188,* 22 (1961) Aug. (6 pp.); **Self-Supporting Arch Spans 150-Foot Canal.** *Pipe Line Ind. 15,* 27 (1961) Aug. (4 pp.)

To its long list of accomplishments, Laclede Gas Company, St. Louis, Mo., recently added another of significance to the gas industry—a company-engineered self-supporting arch pipe span that carries a new gas supply line across Coldwater Creek in north St. Louis County. Only one of its kind in the country, the arch spans the 150-ft creek, rises 20 ft vertically, and becomes part of a new 11-mile high-pressure supply line. Story of the unique arch span—how it was designed and built—is detailed.

**Trunkline's New Road Boring Technique.** V. R. Kincheloe. *Pipe Line Ind. 15,* 25 (1961) Aug. (2 pp.)

By using an oil-water emulsion between the casing and the soil, Trunkline Gas Company was able to bore a hole for 34-in. casing through 320 ft of sandy clay which had resisted conventional road-boring methods. Technique is described.

### Pipeline Operations

**Annual Directory of Pipelines. 1961-62 Issue.** *Pipe Line News 33,* June 15, 1961 (entire issue).

Directory comprises oil and gas pipeline companies, gas distribution companies, their executive and operating personnel, and pertinent data on mileage, pump and compressor stations. Categories of interest include: A.G.A. underground gas storage report; crude oil pipelines; products pipelines; natural gas pipelines; gas distribution companies; underground gas storage fields; engineering services; foreign pipelines, and new pipeline companies.

**Economic Factors of Pipeline Operation.** J. D. Graham. *Petrol. 24,* 307 (1961) Aug. (3 pp.)

In view of the plans for the construction of two U.K. product pipelines over 70 miles long—the product pipeline from the Esso refinery at Fawley to a terminal near London Airport, and the ethylene pipeline from Fawley to the I.C.I. petrochemicals plant now under construction at Severnside—the principal points concerning the economics of pipeline construction and operation discussed by the author come at an opportune time. Of significance is his view that it is not an economic proposition to construct a pipeline unless it is to carry 300,000 tons/yr or more over about 70 miles.

### Telemetering

**Telemetering Helps Peoples Gas Keep Pace.** N. H. Bollinger. *Am. Gas J. 188,* 20 (1961) Sept. (3 pp.)

Conversion to natural gas in 1959 brought many changes in operational procedures and gas dispatching to Peoples Gas System, which serves the greater Miami and Tampa areas of Florida. Company operates two divisions: the East Coast Division (serving an area from Ft. Lauderdale to the south end of Miami Beach) and the West Coast Division (serving the city of Tampa and surrounding communities). Article discloses how multiplexed telemetering has helped solve many of the distribution problems.

### Welding

**Esso Refines Automatic Arc-Welding.** J. W. Nelson, G. E. Faulkner, P. J. Rieppel and H. C. Cook. *Pipeline Eng. 33,* 40 (1961) Aug. (7 pp.)

Excellent quality, high welding speeds, low manpower requirements, elimination of weld backing rings, and elimination of conditions that cause underbead cracking characterize a new automatic process for arc welding girth joints in steel pipelines in a fixed horizontal position. Chief problem of keeping molten steel from flowing out of the weld joint in the vertical overhead positions has been overcome. Automatic process permits: present pipeline construction rates to be matched or exceeded because welding speeds are as high as 55 in./min; single-pass welds in pipe with wall thicknesses of 5/16 in. or less; and adaptability to all pipe diameters. Automatic process in general is a method for adapting $CO_2$-shielded consumable electrode arc welding to pipe girth welding operations.

**Hydrogen Service Failures of Welds with Insufficient Alloy Content.** R. W. Manuel. *Corrosion 17,* 435t (1961) Sept. (2 pp.)

Low chromium-molybdenum alloys were used successfully in refineries to prevent hydrogen damage. Nevertheless, welds failed under certain conditions after long exposure to hydrogen. A case history is discussed involving a weld in the channel of a reactor charge-effluent exchanger which saw service at 950°F and at hydrogen partial pressure of 375 psi. It was found that the welds failing in service had inadequate chromium and molybdenum contents.

## 6. GAS AND LPG STORAGE

### Gas Holders

**Gas Storage and Grid Control Problems.** D. L. Copp. *Gas World 154,* 174 (1961) Aug. 5 (3 pp.)

Author discusses the problem of economics of storage in relation to gas distribution. He discusses gasholders in general, their location along the distribution grid, the function of the holder, temperature costs, engineering expenditures, pipe thickness and pumping costs.

### LPG

**Apparatus and Method of Handling Liquefied Gas Mixtures.** G. R. Benz (assigned to Phillips Petroleum Co.) U. S. 2,993,343 (1961) July 25.

A handling system for storage of two liquefied gaseous hydrocarbons is claimed. This comprises a tank with an upper outlet line, and a preset pressure control valve for withdrawing vapor. A second outlet line extends from the lower portion, with vaporizing means arranged to gasify withdrawn liquid. The two lines merge into a common junction line for mixing the withdrawing vapors.

### Methane Liquefaction

**Static Storage of Liquid Methane. Part 2.** C. I. Kelly. *Petrol. Times 65,* 493 (1961) July 28 (4 pp.)

Author continues his article by talking about liquefaction storage and regasification units used in the United States. The Lake Charles, La., and Canvey Island, England, storage units are then discussed in terms of construction and operational cost. Work carried out in France on storage facilities for liquid methane is mentioned. Article concludes with an analysis of possibilities for further cost reductions in the operation of storage facilities. (For Part 1, see *Gas Abstracts 17,* 135.)

**Liquid Methane Considered for West Coast Use.** *Oil Gas J. 59,* 61 (1961) Sept. 18.

Liquefied natural gas from Alaska could start moving into the Pacific Coast energy market within a few years. Recent study shows that LNG could be brought to the Los Angeles or San Francisco market from Alaska for $.50-$.55/MCF, as compared with $.42 paid in California for some out-of-state gas, and a proposed price of $.45 for gas coming through the projected Texas-through-Mexico line to Los Angeles. Article outlines four-step system that would have to be built if the Alaskan LNG were to be moved to Los Angeles at the rate of 300 MMCF/day.

### Storage

**When Does Vapor Recovery Pay Off?** R. E. Weldon, Jr. *Oil Gas J. 59,* 102 (1961) Sept. 11 (4 pp.)

Gas vented from lease storage batteries in the United States is worth about $35,000,000/yr. Large-volume storage areas are ideal for vapor-recovery systems, but small leases are applicable, too. Author shows how to evaluate leases to determine whether or not a recovery system is economically feasible.

### Underground Storage

**Present Status of Underground Storage of Natural Gas in Southern Ontario and Quebec.** R. P. Charbonnier. *Mines Branch Inf. Circ. 121.* (Ottawa, Canada; 1960; 24 pp.)

Various aspects of underground gas storage in Canada are considered, including an example of evaluation of market requirements in southern Ontario, a survey of the design and operation of partly depleted fields and aquifer reservoirs, and some cost data. The present facilities and future possibilities of gas storage in southern Ontario and Quebec are also studied. Results show the desirability of further investigations of the storage gas pool possibilities in those areas.

**Salt Characteristics as They Affect Storage of Hydrocarbons.** W. R. Aufricht and K. C. Howard. *J. Petrol. Tech. 13,* 733 (1961) Aug. (6 pp.)

Results of laboratory tests, field tests and field observation of salt characteristics pertinent to either the storage of hydrocarbons or the disposal of industrial wastes are given. Significantly dry salt may be sufficiently permeable to allow appreciable flow of nonaqueous fluids. This flow appears to occur along crystal boundaries and cleavage planes and through bands of impurities, including dehydrated shales or mudstones. Present data indicate that water, even in very small quantities, materially affects these characteristics.

**Understanding Underground Storage—the Overall Picture.** P. W. Sherwood. *Butane-Propane News 23,* 54 (1961) Sept. (2 pp.)

Underground storage capacity for LPG increased 24% during 1960. In the past six years, it has increased 542%. Four types of underground storage are suitable for LPG: 1) salt domes and salt layers; 2) mined caverns; 3) oil, gas and water sands; and 4) miscellaneous manmade or natural cavities. Author discusses basic facts of underground storage.

**Understanding Underground Storage—Operating Closeups.** G. P. Jennings. *Butane-Propane News 23,* 58 (1961) Sept. (3 pp.)

Details of three common methods of underground storage—mined caverns, salt dome caverns and salt bed caverns—are outlined from the operational standpoint. Material presented is based on information assimilated from over 50 underground storage operators.

## 7. MANUFACTURED GAS AND CHEMICAL PROCESSING

### Aromatics

**Remove Sulfur from BTX with Sodium.** V. L. Hansley, L. M. Watson and M. Faye. *Petrol. Refiner 40,* 127 (1961) Aug. (4 pp.)

Relatively simple process—which uses metallic sodium—has been evolved for desulfurizing coke oven light oils. The sodium reacts with thiophene and other sulfur bodies to form sodium sulfide, and gives a benzene fraction, a benzene-toluene cut, or a benzene-toluene-xylene cut with a thiophene content below 1 ppm. Operating costs range from 1.5 to 0.86 cents/gal, based on plant capacity. Investment costs are correspondingly low, ranging from $200,000 to $350,000 for plants treating 10-30,000 gal/day of light oil.

**Thermal and Catalytic Decomposition of Hydrocarbons.** A. J. deRosset and C. V. Berger. *Ind. Eng. Chem. 53,* 680 (1961) Aug. (4 pp.)

Most significant industrial development has been the commercialization of hydrodealkylation of alkyl aromatics to produce benzene and naphthalene. Several processes have been announced, and one, Hydeal, is in commercial operation in several locations. Technique provides a new source of benzene and naphthalene in high purity for the growing petrochemical industry. The hydrocracking art continues to be active for the production of motor fuels as well. Low methane yield in this process was exemplified by the "paring" reaction of hexamethylbenzene.

### Butane

**Modern HF Alkylation Unit Solves Surplus Butane Problem.** A. Hegarty. *Petrol. 24,* 311 (1961) Aug. (2 pp.)

The British American Oil Co. has recently completed a modern hydrofluoric acid alkylation unit at their Clarkson, Ont., refinery. This has solved the problem of finding an outlet for surplus refinery butane and also has provided a means of increasing the road octane of finished gasolines. Plant is described.

### Carbon Monoxide

**Removing Carbon Monoxide from Ammonia Synthesis Gas.** H. C. Andersen and W. J. Green, *Ind. Eng. Chem. 53,* 645 (1961) Aug. (2 pp.)

Carbon monoxide can be removed from ammonia synthesis gas to a concentration of less than 10 ppm by

selective oxidation over platinum catalysts at pressures of 100 to 200 psig, as well as at low pressures. Process conditions were developed for adiabatically treating streams containing up to 2% CO. When the inlet CO is greater than 0.5%, two-stage operation is indicated. The first stage operates with one volume of steam per volume dry gas to minimize temperature rise; the second stage can be operated without steam dilution. Higher inlet CO values may be handled in cooled reactors.

### Carbonyl Sulfide

**Preparation of Carbonyl Sulfide.** F. Applegath and R. A. Franz (assigned to Monsanto Chemical Co.) U. S. 2,992,898 (1961) July 18.

Process for producing carbonyl sulfide is claimed. It comprises reacting carbon monoxide with sulfur dispersed in a liquid reaction medium consisting essentially of a hydroxy-substituted tertiary aliphatic amine at a temperature in the range of 25° to 300°C.

### Catalysis

**Correlations in Heterogeneous Catalysis.** M. Boudart. *Chem. Eng. Progress 57,* 33 (1961) Aug. (9 pp.)

Based on a literature survey, author presents an outline of types and classes of correlations in catalysis. Examples, together with their underlying concepts and limitations, are included.

**Catalyst Replacement Economics.** P. R. Walton. *Chem. Eng. Progress 57,* 42 (1961) Aug. (4 pp.)

Analyses shown are for the general case where the simplifying assumptions are followed. Experimental data indicate that these patterns of catalyst behavior are frequently encountered. Therefore, method described may permit rapid and accurate analysis of the costs associated with catalyst degradation in static bed reaction systems.

**Metals Poisoning of Cracking Catalysts.** R. E. Donaldson, T. Rice and J. R. Murphy. *Ind. Eng. Chem. 53,* 721 (1961) Sept. (6 pp.)

Effects of metals contamination of cracking catalysts have been determined using a laboratory procedure which closely duplicates commercial fluid-cracking operations. Sulfur-resistant natural and high-alumina synthetic catalysts were shown to be more resistant to vanadium poisoning than low-alumina synthetic catalyst. At fresh catalyst makeup rates sufficiently high to increase equilibrium activity, the detrimental effects of vanadium poisoning on product distribution are decreased. With sulfur-resistant natural catalyst, the effect of a given vanadium deposit is relatively independent of the age of the deposit. Nickel contamination causes greater deterioration in product distribution than does an equivalent amount of vanadium contamination.

**The Chemisorption of Ethylene on Nickel-Silica.** P. W. Selwood. *J. Am. Chem. Soc. 83,* 2853 (1961) July 5 (5 pp.)

Sorption of ethylene on a nickel-silica catalyst was investigated over the temperature range 0° to 130°C. Methods used were the change of magnetization in the nickel and analysis of the products of hydrogenation. At the lower temperature on this system the ethylene is adsorbed associatively, but as the temperature of adsorption is raised, dissociation and rupture of the carbon-carbon bond become increasingly significant. Large additional volumes of ethylene may be taken up by the nickel if the ethane formed by self-hydrogenation is removed. At 130°C, flowing ethylene quickly converts all the nickel to a nonmagnetic carbide. Treatment of the carbide with hydrogen at 130°C restores the magnetization with the liberation of pure methane.

### Coal Gasification

**Britain's First High-Pressure Gasification Plant.** *Chem. & Process Eng. 42,* 319 (1961) July (4 pp.)

The Westfield works, recently built by the Scottish Gas Board at a cost of £6.6 million, is the first plant in Britain to utilize the Lurgi high-pressure gasification system. It therefore represents a new era in gas manufacture. Article describes several chemical engineering aspects of this plant.

**Particle-Size Reduction of Coal by Attrition in a Tube.** J. L. Konchesky, P. G. Salgado and R. F. Stewart. *U. S. Bur. Mines Rep. Invest. 5824.* (Washington, D. C.: U. S. Govt. Print. Off., 1961)

In gasifying pulverized coal with steam and oxygen, the particle size of the coal fed to a gasifier should be as small as economically possible. A potential way to achieve this advantage is to reduce the particle size of the coal by passing the coal-steam mixture at high velocity through a heated tube coil before the mixture enters the gasifier. To evaluate this method, coal-water slurries were flashed in externally heated metallic tube coils to determine the extent of size reduction. The first of two different laboratory-scale apparatus reduced the average particle diameter of subbituminous C coal from 190 to 110$\mu$ at an outlet velocity of 330 ft/sec. At the same outlet velocity, a second apparatus reduced the average particle diameter from 250 to 140$\mu$.

**Underground Gasification of Coal: Operation of Multiple-Path System.** J. P. Capp, R. W. Lowe and E. F. House. *U. S. Bur. Mines Rep. Invest. 5830.* (Washington, D. C.: U. S. Govt. Print. Off., 1961)

Feasibility of simultaneously burning several paths through a coal bed to develop a multiple-path underground gasification system was investigated. Boreholes were drilled through the overburden and into the coal and arranged in a circle approximately 50 ft from a central borehole. In one experiment, in an area which had previously been hydraulically fractured, air was injected at the center borehole. The coal was ignited at the other boreholes and the fire fronts traveled toward the center, counter to the flow of air, to backward burn paths through the coal bed.

### Ethylene

**Effect of Feed Composition on the Economics of Ethylene Production.** J. A. Knaus and J. L. Patton. *Chem. Eng. Progress 57,* 57 (1961) Aug. (5 pp.)

It is believed that the effect of composition of light naphthas on pyrolysis product distribution can be predicted from the analysis of the feedstock accurately

enough for feedstock evaluation. Variations in feed composition in the light naphtha range markedly affects the ratio of byproducts to ethylene. Investment and operating costs show significant variations as feedstock composition is changed. In the production of ethylene from light naphthas, feedstock selection can be employed as a tool to control the simultaneous production of byproduct olefins, diolefins, and aromatics to meet different market situations.

**Mid-Continent Refiners Now in Position to Bid for Ethylene Manufacture.** J. Chrones and A. R. Johnson. *Oil Gas J. 59,* 71 (1961) July 24 (3 pp.)

Low-cost natural gas and natural gas liquids have been the chief factors contributing to the rise of the Gulf Coast as the major supplier of ethylene. Light straight-run naphtha, which has been a principal source of ethylene in Europe, has become an ethylene feedstock on the Gulf Coast. The use of this or similar liquid-petroleum feedstocks, reduces or even reverses the feedstock advantage which the Gulf Coast has enjoyed. Study shows that the production of ethylene at a refinery with established markets is an attractive venture, since it uses existing products, poses no marketing problem for new byproducts, provides a starting point for future byproduct petrochemicals, and enables the refinery to shift balances to take advantage of varying market situations.

## Hydrocarbon Recovery

**Lean-Gas Processing and Marketing in South Louisiana.** H. C. Bozeman. *Oil Gas J. 59,* 110 (1961) Aug. 14 (6 pp.); **Payoff Plant for Lean-Gas Venture.** T. H. Arnold, Jr. *Chem. Eng. 68,* 104 (1961) Aug. 7 (3 pp.)

Article tells of one company's decision to make direct measurement of residue gas, plant fuel, products, and vented vapors, and to design an extraction plant with a low-temperature-absorption process and high thermal efficiency. The three parts of the plant system are: a 450-MMCF/day extraction plant at Cow Island in Vermilion Parish, La., the Riverside fractionation plant near Geismar, La., and the 87-mile Sibon pipeline connecting the two plants. The extraction plant currently is being expanded to a capacity of 600 MMCF/day.

## Hydrogenation

**Hydrogenation and Dehydrogenation.** B. T. Alexander, D. J. Batliner, W. M. Keely and F. J. O'Hara. *Ind. Eng. Chem. 53,* 767 (1961) Sept. (5 pp.)

Review of 1960 literature shows considerable increase of interest has taken place in fundamental studies; oil and fat hydrogenation; acetylenes, olefins, and aromatics; petroleum, coal, and related materials; and dehydrogenation. The $NH_3$ synthesis field showed a slight increase in activity, whereas hydrogenation of carbon oxides received approximately the same attention as in the previous coverage. Interest in the oxo synthesis and in hydrogenation of miscellaneous organics experienced a decline. There was an increase in the number of catalyst preparations for hydrogenation and dehydrogenation processes.

## Methanation

**Pilot Plant Development of the Hot-Gas-Recycle Process for the Synthesis of High-BTU Gas.** D. Bienstock, J. H. Field, A. J. Forney and R. J. Demsky. *U. S. Bur. Mines Rep. Invest. 5841.* (Washington, D. C.; U. S. Govt. Print. Off., 1961)

A high-Btu gas can be synthesized by the catalytic methanation of a mixture of 2.5 to 3 parts of hydrogen to 1 part of carbon monoxide, obtained in the gasification of coal, using a steel catalyst followed by Raney nickel in a hot-gas-recycle system. Conversion of 99% of the $H_2 + CO$ yields a fuel gas with a heating value of 983 to 1130 Btu/CF containing 78 to 96% methane, no carbon monoxide, and very small amounts of unsaturated hydrocarbons. With the steel catalyst alone, conversions were 85 to 90%, giving a fuel gas of 810 to 860 Btu/CF, or 847 to 975 Btu on a $CO_2$-free basis.

## Mixed Gas

**A Gas Plant Built to Stay Shut Down.** B. Altman. *Compressed Air 66,* 6 (1961) July (5 pp.)

New $1,500,000 propane-air peak shaving plant, with capacity of 30 MMCF/day was never needed. Yet it saved Omaha's Metropolitan Utilities District $1,386,000 by providing a source of fuel for the coldest days last winter. Economics of this paradox are explained.

**Remote Controlled Propane-Air Plant Features Fully Automatic Starting.** *Am. Gas J. 188,* 28 (1961) Aug. (5 pp.)

Orange and Rockland Utilities, Inc., Spring Valley, N. Y., has recently completed a propane-air peak-shaving plant that features fully automatic starting from a completely inactive state upon the transmission of a single remote control signal. New plant, located at Middletown, N. Y., is controlled from the gas system operating center in Spring Valley, some 50 miles away. The plant's capacity is 7500 MCF/day with a maximum delivery pressure of 100 psig. Gas is produced at a constant heating value of 1450 Btu.

## Ore Reduction

**Natural Gas and Oil Injection in Blast Furnaces.** *Coke and Gas 23,* 333 (1961) Aug. (3 pp.)

Survey, prepared by a special correspondent, deals mainly with American attempts to improve fuel economy in iron production by using reducing agents other than coke. He gives a brief survey of experimental oil-injection in a Canadian blast furnace, and then describes experiments carried out by an American oil firm to inject heavy residual oil into the bottom of a blast furnace. Finally the experimental use of natural gas for blast furnace operation is discussed.

**Success for H-Iron but No Revolution.** *Business Week No. 1668,* 73 (1961) Aug. 19.

Direct reduction of iron ore, while commercially feasible, will not replace the blast furnace, according to an announcement by Bethlehem Steel Corp. Report tells of the culmination of a 10-year program to perfect the H-iron cycle. Method uses hot hydrogen in a continuous process to convert the iron oxide in powdered ore directly to metallic iron. Company has shutdown 110 ton/day pilot plant after successful testing program.

### Reformed Gas

**The Thermodynamic Study of the Reforming of Hydrocarbons and Its Application to Autothermic Generators.** J. Ribesse and C. van Maele. *Inst. Gas Eng. J. 1,* 631 (1961) Sept. (13 pp.)

First part of study establishes the thermodynamic equilibrium conditions for the mixture of hydrocarbon, oxygen and steam, in order to determine the theoretical composition of the reformed gas and the reaction temperature in an autothermic system. The second part gives a few industrial operating results of autothermic generators, principally in the field of peak-load town gas production. Autothermic processes are an adequate answer to the problem created by peak-load demands, because of their great flexibility of operation, very high thermal efficiency, and small capital cost through simplicity of installation.

### Shale Oil

**Carbonization of Oil Shale in a Compact Moving Solids Bed.** E. V. Murphree (assigned to Esso Research and Engineering Co.) U. S. 2,992,975 (1961) July 18.

System of oil shale carbonization is claimed in which a shell containing superimposed cooling combustion, retorting and preheating zones is traversed downwardly by coarse shale. These moving beds of shale are heated by an upflowing stream of entrained fine shale particles. Oil vapor is withdrawn from an intermediate retorting zone, and fine shale-suspension is recycled from the top of preheater. The latter may be reheated in an outside vessel.

### Synthetic Fuels

**The Mechanism of the Synthesis of Hydrocarbons from Carbon Monoxide, Hydrogen and Ethylene.** E. J. Gibson and R. W. Clarke. *J. Appl. Chem. 11,* 293 (1961) Aug. (7 pp.)

The distribution of $^{14}C$ between the various carbon atoms in the $C_6$ and $C_7$ chains of the product, formed when a mixture of $H_2$, $C_2H_4$ and $^{14}CO$ is passed over a cobalt Fischer-Tropsch catalyst, has been determined. Most of the radioactivity is concentrated in the carbon atoms in the center of the chains. Some conclusions are drawn regarding the relative roles of adsorbed hydrocarbon and oxygen-containing radicals in the formation of hydrocarbon chains.

### Synthesis Gas

**Manufacture of Synthesis Gas.** H. V. Atwell (assigned to Texaco, Inc.) U. S. 2,992,907 (1961) July 18.

Method is claimed for converting a hydrocarbon fuel into synthesis gas by oxidation. This comprises preheating the fuel to 800°F, and charging it with oxygen and steam to a tubular reaction zone at gas velocities above 50 ft/sec. The zone is then cooled to maintain temperatures within 1300-2000°F. Hydrogen content is controlled by the amounts of steam added.

### Water Gas

**World's Largest Single Unit Carbureted Water Gas Plant.** G. Milner and N. G. Mather. *Gas World 165,* 198 (1961) Aug. 12 (4 pp.)

A 9 MMCF/day guaranteed (and 12 MMCF/day peak load) carbureted water gas plant has been placed in operation for the Mortlake plant of the Australian Gas Light Co., Sydney, Australia. Details are given of improved features of the large units, which provide continuous production of base-load 550 Btu gas, completely automatic operation, automatic control and instrumentation, and future adaptation to Bunker C oil.

## 8. GAS DISTRIBUTION

### Distribution Systems

**A Refresher Course in Gas Production, Transmission, Distribution and Utilization. Part 4: Gas Transmission and Distribution.** I. Deutsch. *Gas 37,* 113 (1961) Sept. (6 pp.)

Basic characteristics of gas flow through a main are presented, and the important variables that affect flow are stressed. The technical discussion is preceded by a brief history of the transmission and distribution of gas. The transition from low- to high-pressure systems due to economic necessity, technological advances, and load growth, are discussed.

**Designing Regulator Units.** J. O. Hulbert. *Gas 37,* 64 (1961) Sept. (3 pp.)

Points considered in article have been used as basic criteria in the design of two regular vaults—one for reducing pounds to pounds and the other for pounds to inches. A number of these units were installed in Vancouver (B.C.) during the winter of 1960-61, and all appear to be working satisfactorily. No unusual complaints have come from the construction or servicing crews, and there have been no serious doubts raised concerning safety. The steel vault is coated on the outside to resist corrosion and hinged lids close on a soft rubber gasket so that the whole box is practically watertight—a sump and syphon are provided for the removal of any water that does enter. Pilots and pressure recorder are mounted on the relief stack for access.

**Gas Handbook Issue.** *Am. Gas J. 187,* 17 (1961) Aug. 15 (entire issue)

Annual edition of this handbook, directed toward the gas distribution field, includes articles on design, construction and materials; corrosion; regulation and measurement; odorization; properties of gases; peak shaving and LPG data and utilization.

### Leakage

**Gas Leakage Detecting Means.** G. Camilli and A. W. Galloway (assigned to General Electric Co.) U. S. 2,989,863 (1961) June 27.

Improved method is claimed for detecting leakage in a sealed gas tank. It comprises inserting in the tank a sealed bulb of gas similar to the tank gas, but at different pressure, and connecting said bulb to a pressure gage, and connecting the tank to an associated but independent pressure gage. Relative variations in tank and bulb pressures will indicate leaks.

**Infrared Leakage Surveys at One-Tenth the Normal Survey Cost.** P. S. Magruder, Jr. *Gas Age 128,* 22 (1961) Aug. 17 (4 pp.)

While not a complete or perfect solution to leak surveying, the infrared-equipped mobile unit provides an efficient, low-cost means of supplementing other survey methods. In Southern California Gas Company's case, surveys are obtained at one-tenth the normal cost. Author reviews his company's experience, gives details of equipment and operation, and lists limitations of methods.

### Metering

**Remote Utility Meter Reading.** A. Brothman and E. W. Lewison. *Instruments and Control Systems 34,* 1462 (1961) Aug. (2 pp.)

Outline is given of some economic advantages and technical details of a commercially available automatic remote meter reading system for domestic and industrial utilities—gas, electric and water.

### Odorization

**Soil Adsorption of Odorant Compounds.** P. B. Tarman and H. R. Linden. (Chicago: *Institute of Gas Technology Research Bulletin No. 33;* July 1961; $3.50)

Results of laboratory studies of the rate and extent of removal of representative odorant compounds from natural gas by selected soil constituents of controlled moisture are presented. Effects of operating conditions of the adsorption of tertiary butyl mercaptan, methyl mercaptan, ethyl sulfide and thiophane were investigated. The adsorbents were stationary beds of montmorillonite, illite and kaolinite clays, peat moss, and Ottawa sand. The experimental program was restricted to these chemically pure sulfur compounds and individual soil constituents, and placed primary emphasis on tests with relatively high inlet sulfur concentrations. Operating variables investigated include space velocity; moisture, oxygen and fogging-oil content of the odorized natural gas; equilibration of the soil constituents with dry and moist natural gas and with dry air; and iron oxide content of the soil.

### Pipe Joints

**Process for Electrothermically Welding Pipe.** D. J. Burke (assigned to Continental Industries, Inc.) U. S. 2,990,-593 (1961) July 4.

Method is claimed for electrothermically welding a tap to a pipe. It consists of placing a mold, having a weld cavity and a tap cavity, around the pipe. The mold is designed so that the weld cavity intersects the tap cavity. After the smaller pipe (tap) is inserted, it is plugged at the point of contact with the larger pipe and centered in the weld cavity. Electrothermically melted copper-nickel thermit is ignited at least at two points in the mold to provide molten weld metal to fill the weld cavity and properly heat both pipe pieces.

### Telemetering

**Security Provisions for Supervisory Control.** *Gas 37,* 49 (1961) Sept. (6 pp.)

After five years' experience with telemetering and remote control, Public Service Electric and Gas Co. (N. J.) was more than ever convinced of the need for centralized supervisory control. As facilities expanded, however, management became increasingly concerned with reliability, and security provisions were given top priority in plans for the permanent gas load dispatching center now located in Jersey City. Telemetering safeguards include detection and backup devices. These, as well as control safeguards, are discussed.

## 9. GAS FUEL UTILIZATION AND APPLIANCES

### Air Pollution

**Air Pollution Control and the Gas Industry.** M. Sterling. *J. Air Pollution Control Assoc. 11,* 354 (1961) Aug. (3 pp.)

Use of gas in space heating, service water heating, and power generation is looked upon quite favorably by air pollution control officials because gas generally can be burned in a smokeless manner. However, this seeming attractiveness should not permit the gas industry to be unconcerned about air pollution control, says author. Gas is used in many other applications where severe local, or areawide air pollution problems could result, such as in heating of varnish kettles, heat treating or annealing of metals, secondary smelting of nonferrous metals, kiln drying operations, and the incineration of waste materials. This latter application is the main subject of article.

**Effects of High Volatile Fuel on Incinerator Effluents.** R. L. Stenburg, R. P. Hangebrauck, D. J. von Lehmden and A. H. Rose, Jr. *J. Air Pollution Control Assoc. 11,* 376 (1961) Aug. (8 pp.)

Previous studies conducted with a cellulose-type fuel have evaluated the effects of operational factors and of fuel moisture content on incinerator emissions. Present study was conducted to obtain similar data from laboratory combustion tests employing a readily vaporizable solid fuel more difficult to burn than ordinary cellulose material. Together, these completed studies will provide background data for evaluating the effects of changes in incinerator geometry. Studies to date have been conducted in a multiple-chamber incinerator having an 8.5 sq ft grate area in a 19.5-cu ft primary combustion chamber, and a 16.5-cu ft final combustion chamber.

**Experience in Smoke Purification at Stazione Sperimentale per i Combustibili.** P. Capponi and F. Renzanigo. *Rivista dei Combustibili 15,* 615 (1961) July-Aug. (20 pp. Italian text.)

Article deals with air pollution produced by liquid fuel domestic heating plants. Review is given of the nature and effects of the main pollutants including solid particles of unburnt fuels and sulfur oxides. Results obtained to date in a series of experiments conducted at the SSC, with two wet smoke cleaners and a dry one installed on an average capacity boiler, are included. Methods employed for plant operation control, and combustion products analysis are presented.

**Exhaust Gas Oxidation on Vanadia-Alumina Catalysts.** W. B. Imnes and R. Duffy. *J. Air Pollution Control Assoc. 11,* 369 (1961) Aug. (5 pp.)

Unsaturated hydrocarbons in auto exhaust are believed to be the primary precursors of photochemical smog. Some of the kinetic studies desirable in evaluating catalysts for their oxidation are discussed. Attention is focused on vanadia-alumina compositions because of favorable unsaturate oxidation.

**Growth of Particles: Droplet Interaction in Aqueous-Disperse Aerosols.** D. P. Benton and G. A. H. Elton. *Discussions Faraday Soc. 30,* 68 (1960) (4 pp.)
Experimental evidence shows that the collection efficiencies of droplets in an aqueous aerosol are a function of the electrolyte concentration. A semiquantitative indication is given of the influence of the Dukhin-Derjaguin diffusional electrokinetic effect on collection efficiencies of droplets of approximately $3\mu$ diameter. A fully quantitative test of the theory awaits experimental data.

**Nucleation of Water Aerosols.** B. J. Mason. *Discussions Faraday Soc. 30,* 20 (1960) (19 pp.)
Paper reviews recent studies of homogeneous and hetereogeneous nucleation of water aerosols involving vapor-to-liquid, supercooled liquid-to-solid, and vapor-to-solid transitions.

**The Growth of Hygroscopic Drops in a Humid Air Stream.** W. L. Dennis. *Discussions Faraday Soc. 30,* 78 (1960) (8 pp.)
Growth rate of drops is of importance in considering the possibility of dissipating natural fog by spraying solutions of hygroscopic substances. The effect of relative humidity and ambient air speed upon the rate of growth of drops of sulfuric acid, calcium chloride, sodium chloride and ammonium nitrate solutions has been investigated for drops in the approximate size range 0.5 to 1.0 mm. It has been found that the rate can be deduced from a combination of well-known equations, in terms of the diffusion of vapor from the drop, the heat balance and a ventilation factor.

**Recommendations for Day-to-Day Monitoring of Atmospheric Pollution Control Effectiveness. Information Report No. 3.** G. W. Bice. Comm. T1-5. *J. Air Pollution Control Assoc. 11,* 387 (1961) Aug. (2 pp.)
Report is concerned with monitoring instruments that can be used by the electric utility industry, both inside and outside the plant, to demonstrate that the plant is not an actual cause of air pollution.

## Burners

**Burner Apparatus and Controls Therefor.** W. H. Dailey, Jr. (assigned to Midland-Ross Corp.) U. S. 2,992,678 (1961) July 18.
Wall burner for a soaking pit furnace is claimed, in which the burner port is built into furnace wall. A venturi tube for air is aligned in the port, and a cluster of fuel gas tubes is centered in the venturi. Pressure lines to the air venturi and to the gas feed are connected to a diaphragm chamber, in which the diaphragm operates a high-pressure piston valve to control the gas and air flow to burner.

**Study of Experimental Range Top Burner Studies.** T. E. Hampel. (Cleveland: A.G.A. Laboratories, Res. Bull. No. 88; Project DA-2-C; Aug. 1961; 38 pp. $2.00)
Bulletin represents the final report of information developed during PAR Program, "Study of Domestic Range Top Section Design." It describes the design and performance characteristics of five new experimental range top burner systems and of a modified version of the high performance top burner developed earlier during this project and described in A.G.A. Laboratories Research Bulletin Nos. 76 and 80. All five systems exhibit performance advantages and disadvantages compared to contemporary designs. An evaluation table is set forth in the summary section of this report. Of the five systems, one involving flush installation of contemporary type range top grates appears to be best suited for practical application.

## Cookers

**How Roper Emphasizes Quality Control.** *Appliance Manufacturer 9,* 32 (1961) Sept. (3 pp.)
Gas range manufacturer spends 6% of all total direct labor costs on extensive program of inspection and quality control. Key to program is a complete feedback of quality information to the product engineering department. Article describes role of company's quality assurance center in achieving and maintaining proper standards.

**Means for Locating the Surface Burners and the Pilot Burner of a Cooking Range.** D. Saponara (assigned to Caloric Appliance Corp.) U. S. 2,991,783 (1961) July 11.
Method is claimed for locating the surface burners and pilot burner of a cooking range. This comprises a stamped bracket with horizontal bottom plate and vertical bent endplates which terminate in extended corner strips. The strips engage in slots in pendant flanges bent down from the main top. When so emplaced, the bracket provides a fixed mounting point, centrally located below the stove top, upon which the burners can be hooked into slots. The pilot burner and flash tubes will be properly located.

## Detonation

**Experimental Investigation of Detonation in Unconfined Gaseous Hydrogen-Oxygen-Nitrogen Mixtures.** L. H. Cassutt. *ARS J. 31,* 1122 (1961) Aug. (7 pp.)
Experimental program has been conducted to determine the detonability of unconfined hydrogen-oxygen-nitrogen mixtures during venting of a missile employing liquid hydrogen as a fuel or during an accidental spill from a storage or missile propellant tan. Mixtures investigated ranged from those formed by hydrogen combining with air to those in which there is no nitrogen dilution. Results of the experimental program have demonstrated that any mixture capable of sustaining a stable detonation wave when confined in a tube will detonate under unconfined conditions if the initiating impulse is sufficiently intense.

## Flame Research

**Combustion of Liquid and Solid Aerosols.** R. H. Essenhigh and I. Fells. *Discussions Faraday Soc. 30,* 208 (1960) (14 pp.)

Paper discusses combustion phenomena in the super micron range since the solid and liquid systems in this range have elements of similarity and contrast that make them particularly appropriate subjects for simultaneous study. Mathematical similarities and chemico-physical dissimilarities between the combustion mechanisms of liquid and solid aerosols are discussed.

**Dispersed Carbon Formation in Acetylene Self-Combustion.** P. A. Tesner. *Discussions Faraday Soc. 30,* 170 (1960) (8 pp.)

Paper is an attempt to perform a theoretical calculation of the process of dispersed carbon formation in self-combustion of acetylene, i.e., when flame propagates in acetylene containing no oxygen. The calculation is based on representations developed by the author involving two-stage formation of dispersed carbon (nucleation and particle growth). A comparison of the calculated results with the experimental data shows good agreement.

**Flat Flame Burner for Burning Undiluted Premixed Hydrogen Fluorine.** S. Kaye. *Rev. Sci. Instruments 32,* 965 (1961) Aug. (2 pp.)

Unit capable of burning hydrogen and fluorine as premixed reactants at low pressures is described. Construction is such that the reaction, which is normally considered spontaneous when the gases come in contact, remains suppressed until the lip of the burner is reached. Combustion occurs over an extremely wide range of fuel-oxidant ratios, including mixtures rich in fluorine. The flame produced by the burner was flat and symmetrical in shape.

**Optical Methods for the Study of Flames in Turbulent Pre-Mixed Gas Streams.** M. D. Fox and F. J. Weinberg. *Brit. J. Appl. Phys. 11,* 269 (1960) July (6 pp.) [From *Appl. Mech. Rev. 14,* 642 (1961) Aug.]

Three optical methods for the investigation of flame processes in turbulent gases are described. All are based on ray deflection by the steep refractive-index gradient occasioned by large temperature and composition changes across the flame front. This is utilized in three different optical systems designed 1) to give a measure of the randomness of orientation of the fluctuating flame front in any locality; 2) to delineate the instantaneous flame-front surface; and 3) to map time-mean deflection (and hence optical path) distributions. Purpose and use of the methods are discussed and illustrated by examples of the records obtained.

From authors' summary

**Theory of Flame-Front Stability.** W. Eckhaus. *J. Fluid Mech. 10,* 80 (1961) Feb. (21 pp.) [From *Appl. Mech. Rev. 14,* 640 (1961) Aug.]

Paper is summary of author's work to determine a theoretical explanation of cellular flames as observed by Markstein. Earlier theories of Landau and Markstein are superseded by consideration of perturbations of flame velocity, diffusion and heat conduction, but work is restricted by present inadequate understanding of even steady-state one-dimensional flame propagation. Assuming flame thickness small compared with cell wavelength, a stability is shown theoretically dependent on mixture properties. Results are in broad qualitative agreement with Markstein's experimental observations that cellular instability generally occurs only with rich mixtures.

D. G. Stewart

## Heat Treating

**How Scovill Continuously Anneals Brass Tubing 60 Ft Long.** G. E. Signor and D. M. Estelle. *Ind. Gas. 39,* 10 (1961) July (4 pp.)

Article describes two major pieces of heat treating equipment used for processing brass and cupro-nickel tubing. These include a 92-ft direct-fired, controlled atmosphere, roller hearth annealing furnace in the redraw line, and a 73-ft convection-heated, controlled atmosphere, roller hearth furnace in the finishing line.

## Industrial Heating

**Ceramic Electronic Component Fired to Exact Properties in Elevator-Car Kiln.** G. D. Smith. *Ind. Heating 28,* 1292 (1961) July (4 pp.)

Process of firing steatite ceramic parts, used in electron tubes, to high temperatures, and effecting necessary changes in their composition, entails critical time-temperature relationship and control. Heating unit, employing radiant burners, was specially designed and built to fire ceramic parts such as cathode support insulators.

**Choice and Economics of On-Off Control for Gas Burners.** E. G. Abell. *Ind. Gas. 39,* 6 (1961) July (4 pp.)

Precision temperature control of industrial gas heating systems may be obtained with numerous arrangements of standard process controllers. Which to use, and when, is a matter of economics as well as processing requirements. Sometimes the cost of burner control systems may be unduly high because of special valves and instrumentation which are not really necessary. Analysis describes five representative control systems for a variety of fluid heating processes—with only the two basic types of gas burners, atmospheric and blast. Temperature control in these five systems is discussed in terms of temperature fluctuations in the heated fluid.

**Gas Heat Is Used in the Banana Ripening Rooms of this Modern Scottish Depot.** *Ind. Gas (British) 24,* 8 (1961) Aug. (4 pp.)

Problem of banana ripening has received a good deal of attention from the gas industry of late, which has resulted in the production of a unit to supersede the conventional methods of banana room heating. Article illustrates a practical application of a unit which ensures uniformity of temperature distribution and at the same time provides protection against flame failure.

**How Natural Gas Fuels Offshore Sulphur Mining Plant.** *Ind. Gas 40,* 3 (1961) Aug. (3 pp.)

World's first offshore sulfur mining plant is located 7 miles off the Louisiana coast in the Gulf of Mexico. It is the principal part of a $30-million Freeport Sulphur Co. project above a major new sulfur deposit known as Grand Isle. Plant employs the Frasch process for bringing the sulfur to the surface. The heating plant, third largest Frasch plant in the world, uses 13 MMCF/day of natural gas.

**Pre-Heating Cupola Combustion Air Speeds Production, Cuts Costs.** F. A. Mellert. *Ind. Gas 39,* 4 (1961) July (2 pp.)

Foundry increased production of one cupola from 29 tons to 36 tons per hr; decreased down time 10%; lengthened refractory life 30 to 50%; saved 78 cents/ton of iron by use of air preheating. Industrial utilization of natural gas has permitted development of an externally fired gas system to preheat combustion air for foundry cupola firing. This is a major breakthrough by the natural gas industry, and has resulted in more economic and efficient operation of a cupola. Simultaneously, smoke and fume nuisance has been eliminated, says author.

**Special Heating Requirements in Production of Precision Investment Castings.** E. M. Broad. *Ind. Heating 28,* 1278 (1961) July (6 pp.)

In the production of investment castings, one manufacturer places due emphasis on heating operations such as curing of investment molds, metal melting, and heat treating of the finished product. A unique layout places the four melting furnaces along one wall, with seven mold curing furnaces and three furnaces for treating finished castings in the center of the building. This provides working and transfer areas so work can be transported, with a minimum of handling operations, to the finishing department.

**The Industrial Use of Town Gas for Drying, Processing, and Heating.** F. J. Brewer and H. N. Ballantyne. *Inst. Gas Eng. J. 1,* 605 (1961) Sept. (21 pp.)

Attention is given to some aspects of building town gas loads in the fields of products finishing, processing and heating. Approach suggested comprises four steps: 1) application of radiant heat for continuous processes, 2) surveying factors that affect the layout of a product finishing plant, with some work study and method study considerations, 3) reference to some lesser known or applied applications of gas-fired radiant heat units in industry and agriculture and 4) considerations in the preparation of a high-temperature, gas-fired radiant heating scheme, with a section on humidity or dewpoint control, and its use in industry.

## Metallurgical Fuels

**Fuel and Energy Requirements for Some Possible Future Steelmelting Processes.** M. W. Thring. *J. Inst. Fuel 34,* 272 (1961) July (7 pp.)

Cold scrap has been melted to make liquid steel with an overall thermal efficiency better than 50% by means of a continuous counterflow melting process, with a metallic recuperator. A proposal for increasing the proportion of scrap which can be melted in the oxygen-blown pneumatic processes is shown. A design is suggested for a hot metal process using various proportions of cold scrap and with oxygen blowing and fuel firing to give flexibility designed from first principles. A proposed design for a combined arc and fuel melting furnace is shown which uses electric energy for the final high-temperature stage, but fuel firing for the preheating of the scrap.

## Refrigeration

**Liquefied Gases—New Techniques in Food Preservation.** *ASHRAE J. 3,* 78 (1961) Sept. (6 pp.); **Temperature Control and the Use of Liquefied Gases.** K. M. Hayes; **Liquid Nitrogen as a Refrigerant in Frozen Food Transportation.** J. J. Kane; **Research Is Needed in Ultra-Low Temperature Food Freezing.** W. A. MaClinn; **Merits of Gas Liquefying Cycles in Processing and Delivery of Frozen Foods.** S. C. Collins.

Article highlights speeches delivered at the ASHRAE meeting in Denver. Speakers probe the difficulties generated by the growth pattern of the frozen food industry, by the mushrooming of consumer outlets and by distribution techniques. It was concluded that liquefied gases hold increasing promise in the area of food preservation usage.

## Space Heating

**Overhead Heating Unit.** H. D. Sterick (assigned to Union Chill Mat Co.) U. S. 2,993,489 (1961) July 25.

Improved radiant-type suspended space heater is claimed. It comprises an elongated rectangular metal shell, with lower long edges turned inward to leave side troughs along an open bottom. Gas supply is piped along the troughs, which carry closely-spaced Bunsen burners directed upward at a slight angle. The burners heat a mat of stainless steel wool, supported on an alloy screen above the plane of the burners. Combustion products pass upward through the mat to a lengthwise domed channel along the top of the shell.

**Space Heating by Ducted Air.** D. M. Brear. *Gas World 154,* 115 (1961) July 22 (5 pp.)

Advent of space heating by fanned warm air is not new, says author. For many years the plenum system of heating and air conditioning has been used in Great Britain, and many important public buildings have been so equipped. More recently, however, a modified version of the plenum system has found considerable favor abroad and has shown a very practical application in the domestic field. Many houses have been fitted with ducted warm air, and the complete absence of pipes, radiators and floor space requirements has, no doubt, done much to promote this method of space heating. System is described.

## Submerged Combustion

**Submerged Combustion Equipment.** W. I. Weisman. *Ind. Eng. Chem. 53,* 708 (1961) Sept. (5 pp.)

Wet-process phosphoric acid exhibits properties that make concentration a difficult problem. Single effect vacuum evaporators have been used with fairly good results, but submerged combustion and other direct-fired concentrators may have some advantages. Ozark submerged combustion concentrators, the Chemico drum concentrator, and the Prayon evaporator are discussed. Carbon brick linings and graphite burners have solved materials of construction problems. Several types of scrubbers now are available to combat the fume problems which have been serious in the past.

## 10. EQUIPMENT AND INSTRUMENTATION

### Computers

**Planned Two-Year Program Provides Smooth Transition to Computer and E.D.P.** E. J. Vetog. *Am. Gas J. 188,* 18 (1961) Sept. (2 pp.)

At the end of 1961, Brooklyn Union Gas Co. will have completed its changeover from punch card machine accounting to electronic data processing. At that time, it will become the first U.S. utility to install the new IBM 7074 data processing system. The computer will be put to work immediately, handling the entire payroll operation and a good portion of the customer accounting and billing. In the engineering area, the 7074 will correlate sendout-temperature data and solve design problems relative to the gas distribution network. Article discusses how company chose the particular electronic system being installed, and what criterion was used in personnel training and recruiting.

**The Uses and Limitations of Computers in Petroleum Engineering Work.** D. S. Ferguson and H. D. Attra. *J. Petrol. Tech. 13,* 625 (1961) July (4 pp.)

In petroleum engineering work computers have been used to solve problems in: 1) surface separation; 2) primary reservoir performance; 3) pressure maintenance and secondary recovery operations; 4) gasfield operations including retrograde behavior, cycling, deliverability, gas plant operations, gas pipeline operations and compressor requirements; 5) economics; 6) maximizing profits or minimizing costs; 7) statistical analysis; and 8) general engineering practices such as drilling, casing design, compressor design and log interpretation. There are advantages and disadvantages in the use of a computer for performing the calculation work that may be required in solving specific problems, and certain of the calculation procedures are not available without the aid of a computer.

### Heat Exchangers

**Design of Direct-Contact Gas Coolers.** J. R. Fair. *Petro/Chem Eng. 33,* 203 (1961) Aug. (8 pp.)

Article reviews present direct-contact practice, summarizes available performance data, suggests tentative design methods, and proposes areas for further engineering research and development. Author advises that in using the material, the scope of each correlation should be noted and tempered as needed to suit the specific design situation at hand.

### Instruments

**How to Select and Specify Primary Measuring Elements.** J. O. Gracey. *Petrol. Refiner 40,* 82 (1961) Aug. (6 pp.)

Designers of complete instrument and control systems start by selecting and specifying the method of measurement. By simplifying this step, process and plant engineers can also take a reasonable approach to instrumentation for their processes. A simplified approach is given to sensing devices for pressure, temperature, rate of flow and liquid level.

### Metering

**Mass Flowmeters Ready to Orbit in the CPI.** G. Bangs *Chem. Processing 24,* 42 (1961) Sept. (10 pp.)

No less than 22 companies are now producing and/or developing mass flowmetering hardware. Three-fourths of these concerns have come into the field in the last three years; none of them could have sold a device to measure mass flow prior to 1952. For the most part they have grown healthy on a diet of space business, and a majority of them are now training their guns on the chemical processing industry. Article tabulates types of devices bidding for the mass flowmeter market.

### Piping

**Use These Tables to Estimate Man Hour Requirements for Installing Welded Piping.** E. J. Mark. *Heating, Piping and Air Conditioning 33,* 103 (1961) Sept. (5 pp.)

Article on piping labor manhours has been developed as a result of an earlier article (see *Gas Abstracts 17,* 4). Comments received from readers pertaining to the definitions and estimating data proposed by the author are incorporated into the data presented. These refined data can serve as a basis on which the engineer can develop better labor cost figures, and therefore better piping estimates.

### Steam Generation

**Considerations on Automation of Industrial Boiler Plant.** A. Wilson. *Fuel Efficiency 9,* 26 (1961) Aug. (6 pp.)

Full automation in every sense of that word is not always economically justified, but semiautomation with a view to ensuring maximum efficiency with minimum of labor is often a sound proposition. All automatic plants within the range discussed in article ought to be capable of operation at an efficiency greater than 75% on a gross C.V. basis over the whole working week. This point is made because of the difficulties of allowing for banking losses and shutdown periods.

### Temperature Measurement

**A Cooled-Tube Pyrometer with Experimental Results Obtained in a High-Temperature Gas Stream.** G. E. Glawe, R. C. Johnson and L. N. Krause. *Nat. Aero. and Space Admin. Tech. Note D-870.* (Washington, D. C.: NASA, Aug. 1961; $0.75; 25 pp.)

Immersion-type pyrometer is described whose primary sensing element is a cylindrical tube in cross flow. The heat-transfer rate to this unit is determined by measurement of the flow rate and temperature rise of a coolant passing through the tube. The heat-transfer rate can then be related to free-stream temperature, after determination of a constant of proportionality by calibration against a reference pyrometer at some convenient lower temperature. Experimental data were obtained in a subsonic exhaust-gas stream over a pressure range of ⅔ to 1½ atmospheres and a temperature range of 1600° to 4400°R.

### Valves

**Gas Valve Servicing.** J. Lee. **Part 1.** *Gas Heat and Comfort Cooling 12,* 37 (1961) July (4 pp.); **Part 2.** *Ibid.,* 44 (1961) Aug. (4 pp.)

Part 1 contains a brief history of the problems faced by the gas valve servicemen. In particular, diaphragm and magnetic valves, and valves for self-generating systems are discussed. Part 2 is concerned with motorized valves (both straight mechanical and hydraulic), and the heat expansion bimetal units.

## 11. MATERIALS OF CONSTRUCTION, AND CORROSION

### Alloys

**Choosing Alloys for 1200°F+ Corrosive Applications.** J. J. Moran. *Chem. Processing 24,* 49 (1961) Aug. (5 pp.)

Selection of the right metal for tough corrosive applications is always difficult. The problem is further complicated if elevated temperatures (above 1200°F) must be considered. To insure getting the best performance for the costs involved, a number of important corrosion mechanisms and related factors must be taken into consideration before the final alloy is chosen. These points, and some of the latest findings pertaining to them, are briefly presented.

### Cathodic Protection

**Cathodic Protection for Gas Distribution Systems.** P. E. Reynolds. *Gas Age 128,* 19 (1961) Aug. 17 (3 pp.)

Study of cathodic protection based on Pacific Gas & Electric Company experience indicates their method to be entirely satisfactory when properly used. The challenge for the corrosion engineer is to apply it in such a manner that maximum benefit will result with a minimum of organization, nuisance, direction and expense.

**Cathodic Protection for an Uncoated Aluminum Pipeline.** J. F. Whiting and T. E. Wright. *Corrosion 17,* 9 (1961) Aug.

Cathodic protection has been used successfully on an uncoated, buried aluminum pipeline used to gather natural sweet gas in the Cantuar, Saskatchewan field of Western Canada. Eleven months after installation of the line without any protection for corrosion control, the pipe was pitted deeply at six different locations. Corrosion has been arrested by application of cathodic protection without any evidence of harmful side effects. A further examination will be made in 1964 when the line will have been under cathodic protection for five years.

**Coatings Formed on Steel by Cathodic Protection and Their Evaluation by Polarization Measurements.** W. J. Schwerdtfeger and R. J. Manuele. *J. Research (Eng. and Instrumentation) 65C,* 171 (1961) July-Sept. (11 pp.)

Three steel specimens were continuously exposed in the laboratory for almost 5 years in city water to which was added 3% by weight of sodium chloride. Two of these specimens were under continuous cathodic protection, one by current from a zinc anode, and the other by current from a rectifier through a carbon anode. The third specimen was left to corrode freely. As a result of the cathodic protection, carbonates and silicates formed protective coatings which eventually reduced the current density required for protection from about 5 to 0.02 ma/ft$^2$. A coated specimen, after being without protective current for 32 days (including 12 days out of the salt water), required only 0.3 ma/ft$^2$ for initial protection.

**Continuous Recording of Pipe-to-Soil Potential vs Distance.** R. L. Davis. *Corrosion 17,* 446t (1961) Sept. (3 pp.)

Equipment and a method useful in conducting a continuous recording of pipe-to-soil and certain other potentials significant in cathodic protection of underground metallic structures are described. Method permits location of hot spots on lines with considerable accuracy, usually within a few feet. Equipment consists of a wheel electrode, mechanically and electrically connected to a recording device which plots distances and potentials continuously as it is rolled along the earth's surface over a pipeline. Practical application is discussed.

**Electrolysis Drainage Switches.** W. T. Luttrell. *Gas Age 128,* 26 (1961) Aug. 17 (3 pp.)

In areas of varying stray and direct currents, the drainage switch becomes a most important part of the solution of the resulting corrosion problems. Author describes the types of switches, their operations and limitations.

**Theory and Application of Deep Ground Anode Beds.** J. F. Tatum. *Corrosion 17,* 26 (1961) Aug. (5 pp.)

Author discusses advantages of deep ground bed anode installations in comparison with surface ground beds. He defines deep bed installation as an isolated current source 200 feet or more below surface of ground. These beds are not cased but are backfilled by pouring or pumping backfill around anodes. A formula for determining hole size, anode type size and number for an installation is presented, and methods of supporting anodes are briefly discussed.

**Use of Pipe-to-Soil Potential in Analyzing Underground Corrosion Problems.** B. Husock. *Corrosion 17,* 391t (1961) Aug. (5 pp.)

Pipe-to-soil potential measurements can be used to distinguish stray current corrosion from galvanic corrosion. General rules are given for the interpretation of a set of potential measurements in evaluating an underground corrosion problem in a nonstray current area. Data reported include potential profiles of: 1) galvanic corrosion activity; 2) pipe subject to exposure from cathodic protection interference; 3) ungrounded coated pipeline; 4) coated pipeline connected to copper grounding system; and 5) bimetallic effect. Several case histories are cited to show actual application of rules in evaluating corrosion problems in nonstray current areas.

## Coatings

**Anti-Corrosive Elastometric Linings for Industrial Use. Part I.** *Corrosion Tech. 8,* 240 (1961) Aug. (4 pp.)

Plant engineer anxious to protect equipment from corrosion can choose from a variety of methods, one of which is to use elastometric lining and coating materials designed to meet a given set of corrosive conditions. What must be known, however, in selecting the right materials and methods are not only the properties of the coatings, but also their limitations. Some properties and uses of linings based on elastomers are considered.

**Coating Systems for Steel at 250 to 1200 F.** G Norman. *Corrosion 17,* 12 (1961) Sept. (5 pp.)

Report concerns 3½-year tests at a Gulf Coast petrochemical plant to find coatings suitable for steel process vessels, piping and equipment operating in the range of 250°-1200°F. Coatings tested include silicones, aluminum-coated steel, aluminum sheathing, alkyds, zinc-rich organics, catalyzed epoxy, air drying phenolics and inorganic zinc silicates. Tests showed best results were obtained using inorganic zinc silicate primers with various topcoats of other materials.

**Industrial Painter Education.** NACE Technical Unit Committee T-6D. *Corrosion 17,* 415t (1961) Aug. (7 pp.)

Detailed account is given of the steps that may be taken by both management and labor to improve industrial painter education. Topics dicussed include the gap between technology and training, benefits to be gained by all parties concerned in improving painter education, coordination of training standards, determination of manpower requirements, tightening of painting specifications, action by industrial management in chemical process and petroleum refinery industries, action by trade unions, apprenticeship programs, and courses of instruction available.

**Preserving Water-Sealed Gas Holders.** R. Nichols. *Corrosion Tech. 8,* 204 (1961) July (6 pp.)

Problems associated with preserving the steel sheeting of water-sealed gasholders have been known for some time. Various techniques have been adopted, e.g., protective painting, oil filming and sacrificial anodes. Paper deals with painting. The two groups of paints used in the experiments were chosen for their 1) blister-suppressing qualities, and 2) good adhesion and water resistance.

**Things You Should Know About Maintenance Coatings.** D. O. Lachmund. *Chem. Processing 24,* 54 (1961) Aug. (6 pp.)

How can the best protective coating for specific needs be determined? Although there is no simple answer to this problem, article presents some information that may make it easier to select the right one.

**Zinc Filled Inorganic Coatings.** *Corrosion 17,* 401t (1961) Aug. (3 pp.)

Report considers in detail the uses, corrosion resistance, and application of zinc-filled inorganic coatings. Environments in which these coatings were exposed and evaluated include water and moisture, acids, oxidizing agents, alkalies, and solvents and oils. Properties of applied coatings considered include temperature limitations, impact and abrasion resistance, aging, toxicity and odor, weight, electrical properties, adhesion and gloss retention. Matters discussed in connection with application include coverage, flammability and toxicity, surface preparation, drying time, curing, baking, inspection and compatibility.

## Corrosion

**Corrosion Problems in a Sinter Plant Exhaust Gas System.** R. J. Schmitt. *Corrosion 17,* 425t (1961) Sept. (5 pp.)

Corrosion that occurred in the carbon-steel exhaust gas system of a larger sinter plant used for agglomerating iron ore fines is described. Corrosion was found to be caused by condensation of sulfurous acid and hydrochloric acid from the exhaust gases. These possible methods of minimizing future corrosion are described: maintaining metal surface temperatures above the acid dewpoint; insulating equipment exposed to weather; and using protective coatings.

**Effect of Solution pH on the Mechanism of Stress Corrosion Cracking of a Martensitic Stainless Steel.** H. J. Bhatt and E. H. Phelps. *Corrosion 17,* 430t (1961) Sept. (5 pp.)

Experiments were conducted to determine the effect of solution pH on the stress corrosion cracking of a specially alloyed martensitic stainless steel, USS 12 MoV stainless in a 3% sodium chloride solution saturated with oxygen. The time for stress corrosion failure was shortest at pH 1 and increased gradually as the pH was increased from 3 to 11. Stress corrosion cracking did not occur when the pH was 11.5 or higher.

**Location of the Half Cell in Measuring Potential of Structures to Earth.** K. G. Compton. *Corrosion 17,* 423t (1961) Sept. (2 pp.)

Significance of errors introduced into the circuits used to measure ground potentials is discussed. Effect of resistances related to distance from the structure being examined is explained.

## Inhibitors

**Use of Oxygen Scavengers To Control External Corrosion of Oil-String Casing.** F. W. Schremp, J. F. Chittum and T. S. Arczynski. *J. Petrol. Tech. 13,* 703 (1961) July (9 pp.)

Paper describes a laboratory study of causes of external casing corrosion and the test work that led to the use of oxygen scavengers to prevent this attack. External casing failures are classified as water-line, casing-casing, collar and body failures. A corrosion mechanism, based on principles of differential oxygen availability, is developed that is consistent with facts known about each kind of failure. The field use of oxygen scavengers is depicted as a direct result of the laboratory study.

## Plastics

**Nylon as an Engineering Material.** M. M. Epstein and B. Bennett. *Battelle Tech. Rev. 10,* 3 (1961) Aug. (6 pp.)

Nylon has been successfully "engineered" into many important and seemingly unrelated jobs. This is because

it possesses some unique properties which make it superior in numerous applications to many metals. It can easily be injection-molded into very complex shapes, and often a single nylon part can replace a multicomponent metallic system. It is also lightweight, having a density ⅐ that of steel and ⅛ that of copper. Among its outstanding properties are its high strength, toughnes, resistance to abrasion, and low coefficient of friction. Article reports on the properties, compositions, and structures, and on recent advancements in methods of preparation for nylons.

**Recent Applications in Corrosive Conditions of Rigid PVC Piping.** D. A. Trebucq. *Corrosion Tech. 8,* 215 (1961) July (3 pp.)

In the thermoplastics group of materials, unplasticized polyvinyl chloride, commonly known as rigid PVC, appears to have made the slowest progress in the United Kingdom. It was introduced shortly after the war, but, as recently as 1958, the annual usage for industrial pipes was estimated at only 500 tons. In the same year, France, Holland and Italy processed approximately 4000, 8000 and 12,000 tons, respectively. Article indicates the scope of the material's applications in corrosive environments.

## 12. ANALYTICAL METHODS AND TESTS

### Analytical Instruments

**Differential Volumenometer for Measuring Minute Volume Changes in Solids.** R. Lowrie and F. Slish. *J. Sci. Instruments 38,* 278 (1961) July (4 pp.)

Design and use of a differential volumenometer for measuring volume changes of solid samples to ±5 ppm are described. The sample, sealed in a reservoir with only a capillary outlet, is covered with mercury, in which it must not be soluble. Any alteration in the sample volume, such as might be produced by heating it while in the volumenometer, is detected as a change in the level of the mercury meniscus in the capillary. Measurements of this level are made while the volumenometer is held at a standard temperature. The volumenometer may be heated to at least 250°C to produce changes in a sample.

### Chromatography

**Analysis of Fuel Gases and Combustion Products.** I. Fells, T. J. Howells and M. A. Patrick. *J. Inst. Fuel 34,* 283 (1961) July (8 pp.)

Factors affecting the efficiency and accuracy of the analysis of combustion gases by gas-solid partition chromatography are discussed both quantitatively and qualitatively. The work was done using equipment incorporating a hydrogen microflame detector and later a katharometer detector. A study of the adsorptive powers of activated carbon, molecular sieve material, silica gel and alumina in terms of gas chromatographic data has shown that these adsorbents can be used as column packing for the separation of gas mixtures at various temperatures. The effects of temperature, pressure and flow rate control, and finally the analysis of the chromatograms are discussed. The results and conclusions given are guides to the selection of the best column(s) and conditions for a particular gas analysis.

**Modified Chromatograph to Record Helium Content of Natural Gas Streams.** C. L. Klingman. *Rev. Sci. Instruments 32,* 822 (1961) July (3 pp.)

Construction and procedure for use of a special purpose chromatograph, designed to analyze small amounts of helium in natural gas streams, are described. Successful use of ordinary solenoid valves for column switching is unique. Automatic-zero circuitry is also mentioned. The instrument has proved to be useful in the reduction of wasted helium in the outlet gas streams from helium extraction plants.

### Coal

**Basic Nitrogen in Coals.** J. C. Brooks and J. W. Smith. *Australian J. Appl. Sci. 12,* 241 (1961) June (5 pp.)

Organic structure of a wide range of coals contains about 1.5-2.0% of nitrogen, but little is known about the type of grouping in which this occurs. A technique based on the sorption of perchloric acid from an anhydrous perchloric—acetic acid mixture has been used for the detection of basic groups in coals. The samples were first dissolved or dispersed in an acid or neutral solvent (phenol, α-naphthol, or phenanthrene). Experiments on a range of coals, from brown to high-rank coking coals, demonstrated that in all cases 50-75% of the nitrogen was in a basic form. The investigation showed for the first time that a major proportion of the nitrogen in a wide range of coals occurs in the form of basic primary, secondary, and tertiary amine groups.

### Distillation

**Molecular Distillation.** K. C. D. Hickman and G. W. Kinzer. *Battelle Tech. Rev. 10,* 9 (1961) Aug. (6 pp.)

There is a growing interest in high-vacuum molecular distillation for chemical purification and processing. The authors present currently available techniques, and discuss the present status and potentialities of this type of distillation.

### Gas Analysis

**A Probe for Studying the Deposition of Solid Material from Flue Gas at High Temperatures.** P. J. Jackson and E. Raask. *J. Inst. Fuel 34,* 275 (1961) July (6 pp.)

Simple and robust air-cooled probe, providing a reproducible and easily manipulated target of known, variable temperature, has been used to study the deposition of fuel-ash constituents from flue gas in boilers. It can realistically simulate heat-transfer elements at metal temperatures up to 900°C in boiler combustion chambers and superheaters. The operating procedure for the probe equipment is described, and methods for examination of collected deposits are recommended.

**Chemical Analyses of Automobile Exhaust Gases for Oxygenates.** C. F. Ellis. *U.S. Bur. Mines Rep. Invest. 5822.* (Washington, D.C.: U.S. Govt. Print. Off., 1961) Interest in the composition of automobile exhaust gases has been greatly accelerated by recent studies. Report presents procedures for chemical analyses of certain oxygenated compounds, procedures for sampling the exhaust gases for these analyses, and the analytical results of some experimental work in which these procedures were used. A stationary 1956 model, 170 horsepower, V-8, dynamometer-mounted engine was used for the study. Exhaust gases produced from a regular-grade Midcontinent gasoline during 15-, 40-, and 60-mph cruise operations were analyzed by chemical methods for formaldehyde, total aldehydes, total carbonyls, total alcohols, carbon associated with the oxygenated compounds, and the oxides of nitrogen.

**Components of Raw Producer Gas.** W. R. Bulcraig. *J. Inst. Fuel 34,* 280 (1961) July (4 pp.)

Article describes the analysis of producer gas into the components contributed by the different producer reactions, i.e., $CO_2$, CO, $CH_4$, $H_2$, $N_2$. The method is useful in assessing the relative value of the different producer reactions and could be used in the examination of gas tests to diagnose producer troubles. The contribution of volatiles from direct distillation of the fuel, including tar, expressed as a percentage of the total calorific value of the raw gas, is estimated to be 40% with a good producer operating on a good quality bituminous fuel.

## Gas Detector

**Electronegative Gas Detector.** R. E. Fox, P. R. Malmberg and R. B. Gosser. *Rev. Sci. Instruments 32,* 898 (1961) Aug. (4 pp.)

Electronegative gas detector has been developed which is capable of measuring one part of $SF_6$ in $10^7$ parts of air. Operation of the instrument is based on the differences between various electronegative gases in the rates of electron attachment at low electron energies, and on the differences of mobilities of the resulting negative ions in an electric field. Instrument operates at atmospheric pressure, and uses a modulated ultraviolet light source to produce at a photocathode pulses of photoelectrons which are attached to produce negative ions. Differences in cathode-anode transmit times of the negative ions result in different phase shifts of the observed cathode current. The measured phase shifts serve to indicate the amount of electronegative gas present.

## Hydrocarbons

**Ring Analysis of High Oxygen Content Samples. A Modification of the n-d-M Method.** C. Karr, Jr. and J. R. Comberiati. *Anal. Chem. 33,* 1420 (1961) Sept. (4 pp.)

The n-d-M method is modified to permit the ring analysis of high oxygen content samples. The modification is based on the comparison of the refractive indices and densities of a number of blended pure aromatic oxygen compounds with the values for the structurally analogous hydrocarbons.

## Nickel

**Extraction and Flame Spectrophotometric Determination of Nickel.** H. C. Eshelman and J. A. Dean. *Anal. Chem. 33,* 1339 (1961) Sept. (4 pp.)

Flame spectrophotometric method is developed for determining nickel. Nickel is selectively extracted with a 4-methyl-pentan-2-one solution of salicylaldoxime. The organic phase is aspirated directly into the flame. The procedure is applied to assays of sheet brass and nickel-chromium steel samples.

## Odorants

**Comparison of Instrumental Methods of Analysis for Odorants and Other Sulfur Compounds in Natural Gas.** P. B. Tarman, B. H. Andreen and D. V. Kniebes. *Gas 37,* (1961) Sept. (10 pp.)

A study was conducted of four instruments for analyzing natural gas for sulfur compounds in trace concentrations. Three of these, the Titrilog, the Austin I-Br 313 Gas Titrator, and the Beckman Mercaptan Analyzer, depend on chemical reactions to measure sulfur content, and do not differentiate individual sulfur compounds. The fourth was a conventional gas chromatograph equipped with an argon ionization diode detector. This instrument appeared capable of measuring individual sulfur compound concentrations at typical odorant levels. Results obtained in the research program indicate that, when calibrated, the Titrilog, Austin I-Br 313 Gas Titrator, and the Beckman Mercaptan Analyzer can be used to obtain reasonably accurate analyses. The gas chromatograph shows considerable promise of becoming an excellent and versatile instrument, but requires further work.

## Olefins

**Spectrophotometric Determination of Olefins.** A. P. Altshuller and S. F. Sleva. *Anal. Chem. 33,* 1413 (1961) Sept. (8 pp.)

Olefins in either the gas or liquid phase are quantitatively determined by spectrophotometric procedure. The olefins react with *p*-dimethylaminobenzaldehyde in sulfuric acid producing a complex with maximum absorbance at 500 mμ. Formaldehydes, aromatic hydrocarbons, and phenols interfere and must be removed. Automobile exhaust and liquid samples are assayed.

## Sulfur

**The Rapid Determination of Sulfur in Petroleum Fractions by X-Ray Absorption of Tritium Bremsstrahlung.** A. F. Pyrah, R. S. Roberton and J. Wiseman. *Anal. Chem. 33,* 1355 (1961) Sept. (6 pp.)

Sulfur content of petroleum products is determined by using the bremsstrahlung emission from a tritium-titanium source. Analyses of samples ranging from gas oils to heavy fuel oils are made rapidly, involving about six minutes per determination. The procedure indicates good accuracy and precision.

## 13. BASIC SCIENCE

### Air Pollution

**Kinetics of Atmospheric Chemical Reactions Involving Aerosols.** R. D. Cadle and R. C. Robbins. *Discussions Faraday Soc. 30,* 155 (1960) (7 pp.)

Paper is primarily concerned with studies of the kinetics of thermal reactions between the particles and the gaseous constituents of the atmosphere. Such studies indicate the speed with which the reactions occur and suggest the mechanisms involved. The application of chemical kinetic theory to heterogeneous atmospheric chemical reactions involving aerosols is discussed from the standpoints of both collision theory and absolute rate theory.

**Nucleation: Homogeneous and Heterogeneous.** W. J. Dunning. *Discussions Faraday Soc. 30,* 9 (1960) (11 pp.)

The Volmer-Weber-Becker-Doring theory of homogeneous and heterogeneous nucleation of liquid and solid particles from a supersaturated vapor phase is summarized briefly. The predictions of the theory are compared with the experimental results obtained by various authors using the cloud chamber method, the method of isentropic expansion through nozzles and the method in which a jet of vapor becomes supersaturated when issued into a cool atmosphere. It is concluded that the theory is in fair agreement with the experiments.

**The Stabilization of Water Mists by Insoluble Monolayers.** H. S. Eisner, B. W. Quince and C. Slack. *Discussions Faraday Soc. 30,* 86 (1960) (10 pp.)

Water mists containing droplets in the size range 2-20 $\mu$ radius have been stabilized by reducing the evaporation rate of individual droplets. This was achieved by dispersing small quantities (0.05-0.2%) of a fatty alcohol in the water by means of a dispersing agent. As the water evaporates the alcohol forms an isoluble monolayer. A theory that explains the action of the monolayer on the basis of Fuchs' equation of droplet evaporation has been shown to be adequate.

### Diffusion

**The Motion of a Small Particle in a Non-Uniform Gas Mixture.** S. P. Bakanov and B. V. Derjaguin. *Discussions Faraday Soc. 30,* 130 (1960) (9 pp.)

Problem of the behavior of a small aerosol particle (smaller than the mean free path of gaseous molecules) in a nonuniformly heated gas mixture is examined on the basis of the Chapman-Enskog method. The velocity at which the particle moves through such a mixture is calculated. A numerical computation is made for a $CCl_4$ + He mixture. Inversion of the particle velocity was observed, i.e., the particle may be attracted to an evaporating drop and repelled from a growing one. By way of particular cases, the velocity of motion has been found for a particle in an isothermal binary mixture and in a simple nonuniformly heated gas.

### Fluid Flow

**Gaskinetics and Gasdynamics of Orifice Flow.** H. W. Liepmann. *J. Fluid Mech. 10,* 65 (1961) Feb. (15 pp.) [From *Appl. Mech. Rev. 14,* 626 (1961) Aug.]

Paper gives the result of a study on the efflux of gases through circular apertures. The problem is considered as an example of a transition from the gas-dynamic to the gas-kinetic regime. The mass flow of helium, argon and nitrogen was measured for a range of upstream pressures corresponding to (mean free path)/(aperture diameter) from about 50 to 5 x $10^{-1}$; within this range the transition from molecular effusion to inviscid, transonic flow takes place. Theory for the two asymptotic limits is discussed, and first-order corrections to the free molecular and inviscid limit formulas are given.

S. Uchida

**Kinematic Formulation of Rotational Gas Flow.** M. Vinokur. *J. Fluid Mech. 9,* 533 (1960) Dec. (10 pp.) [From *Appl. Mech. Rev. 14,* 626 (1961) Aug.]

It is shown that for the steady isoenergetic rotational flow of an ideal gas, both the specific enthalpy and the speed of sound can be expressed as functions of the velocity. As a result, it is possible to formulate the equations of motion so that the velocity is the only dependent variable. For a gas whose enthalpy and sound speed are functionally related, the results are a generalization of those for a perfect gas. If the enthalpy and sound speed are independent variables, the new formulation leads to a single vector equation whose solution completely determines the flow.

R. C. Binder

**Two-Phase Slug Flow.** P. Griffith and G. B. Wallis. *J. Heat Transfer 83,* 307 (1961) Aug. (12 pp.); **Discussion.** R. A. S. Brown and G. W. Govier. *Ibid.,* 318 Aug. (3 pp.)

When two phases flow concurrently in a pipe, they can distribute themselves in a number of different configurations. The gas can be uniformly dispersed throughout the liquid in the form of small bubbles. There can be large gas bubbles almost filling the tube. There can be an annulus of liquid and core of vapor with or without drops of liquid in it. The interface can be smooth or wavy. When the distribution of the phases is described, the flow regime is specified. Such a description is necessary before any mathematical model can be constructed which will predict a quantity such as pressure drop.

### Heat Transfer

**A Review of Heat Transfer Literature 1960, Part 2.** E. R. G. Eckert, T. F. Irvine, Jr., E. M. Sparrow and W. E. Ibele. *Mech. Eng. 83,* 50 (1961) Aug. (8 pp.)

Article includes review of literature on convection from rotating surfaces; combined heat and mass transfer; change of phase; radiation; liquid metals; low-density heat transfer; measurement techniques; heat transfer applications; and thermodynamic and transport properties. Bibliography cites 189 references on these topics.

**Designing for Unsteady-State Heat Transfer in Packed Beds.** O. K. Crosser. *Petro/Chem. Eng. 33,* 190 (1961) Aug. (8 pp.)
Time-saving new design method for vessels that utilize unsteady-state heat transfer between gases and solid particles in a packed bed also offers these important advantages: 1) it can accommodate most of the complications which might occur; 2) it provides a fundamental basis for analysis of data; 3) the same equations describe both the heat and mass transfer cycles; and 4) detailed mathematical analysis is not required.

**Heat Transfer to Laminar Flow Across a Flat Plate with a Nonsteady Surface Temperature.** R. D. Cess. *J. Heat Transfer 83,* 274 (1961) Aug. (6 pp.); **Discussion.** C. L. Tien. *Ibid.,* 279 Aug. (2 pp.)
Forced convection heat transfer is considered for laminar flow across a flat plate whose surface temperature varies with time. The case analyzed first is that of a step change in surface temperature, and series solutions are obtained which apply for both small and large time spans. These series results are used to construct an approximate solution which describes the entire time history of the nonsteady heat transfer process.

**Predicting Heat Transfer Coefficients for Film Flow. Part 1. Theory.** A. E. Dukler. *Petro/Chem. Eng. 33,* 198 (1961) Aug. (3 pp.)
Theoretical analysis published recently by the author treats in detail the problem of laminar and turbulent film flow. By using this analysis, heat transfer coefficients can be calculated with accuracy for both laminar and turbulent film flow. Article introduces practical application of this theory.

## Hydrocarbons

**Molecular Detachment Processes in the Vacuum uv Photolysis of Gaseous Hydrocarbons. I. Ethylene. II. Butane.** M. C. Sauer, Jr. and L. M. Dorfman. *J. Chem. Phys. 35,* 497 (1961) Aug. (6 pp.)
Photolysis of ethylene and of butane has been studied at room temperature with light of 1470°A. The results of isotopic studies, along with a detailed examination of the products of reaction, establish conclusively that molecular detachment processes are of major importance in the primary decomposition of the photo-excited states formed.

## Mass Transfer

**Mass Transfer from Individual Gas Bubbles.** F. H. Deindoerfer and A. E. Humphrey. *Ind. Eng. Chem. 53,* 755 (1961) Sept. (5 pp.)
A 150-cm water-filled column was used to observe dissolution of ascending $CO_2$ bubbles. Mass transfer coefficients calculated from motion picture observations indicate that bubbles between 0.3 and 0.6 cm in diameter do not achieve steady-state circulation during their 150-cm ascent. Circulation within a bubble apparently decays rapidly with time, and the concept of a perfectly circulating bubble appears unsound. Neither Higbie's penetration theory nor boundary layer considerations adequately correlate the mass transfer coefficients obtained.

## Plasmajets

**Controlled Plasmajet Heating.** *Ind. Heating 28,* 1286 (1961) July (2 pp.)
Fundamental deficiency of the air plasmajet—namely, its inability to control its own output of intense heat—has apparently been eliminated by modifications recently made to facilitate a refractory materials development program. The main improvement in the air plasmajet involves the use of an aerodynamic nozzle between the heat source and a test chamber.

## Propane

**Propane Is a Selective Solvent.** V. Anastasoff and K. E. Train, *Ind. Eng. Chem. 53,* 662 (1961) Aug.
Propane is commonly used as a solvent for deasphalting residual petroleum stocks. Because of the difficulty of analyzing asphalts and oils from vacuum distillation residues, separations are usually described qualitatively in terms of physical properties. To estimate the selectivity of propane in more detail, a predominantly aromatic oil of low enough molecular weight to be analyzed conveniently by mass spectrometry was extracted with propane in a multistage deasphalting tower. Analyses of the products confirm that propane preferentially dissolves both the lower molecular weight and the less aromatic components.

## Shock Waves

**Shock-Wave Curvature at Low Initial Pressure.** R. E. Duff and J. L. Young, III. *Phys. Fluids 4,* 812 (1961) July (4 pp.)
The shape of the primary shock wave in a shock tube has been measured by recording the time of arrival in argon at an array of piezoelectric detectors located along a diameter of a 28.6 mm i.d. shock tube operated at an initial expansion chamber pressure of 0.34 mm Hg. The following conclusions were drawn from the results: 1) shock-wave tilt was negligibly small under the conditions; 2) shock-wave curvature is independent of shock strength for shock Mach numbers from 1.8 to 6.3; 3) the shock-front shape is nearly spherical; 4) the axial extent or the bulge of the curved shock is approximately 1 mm. The axial extent of a shock in argon was also measured over the range of initial pressure from 0.1 to 20 mm Hg.

## Viscosity

**Viscosimetry of Gas in the Laboratory.** E. Caffo. *Rivista dei Combustibili 15,* 635 (1961) July-Aug. (12 pp. Italian text.)
Description is given of a new type of gas viscosimeter which enables the determination of the relative viscosity of air, once the specific weight is known. The apparatus is formed by two different flowmeters arranged in series. The first measures a pressure drop whose value is mainly influenced by the specific weight of the gas, the second a pressure drop whose value is mainly influenced by the viscosity of the gas. If the pressure drops in both flowmeters and the specific weight of the gas are known, the viscosity of the gas relative to air may be calculated.

# Services Available to GAS ABSTRACTS Readers

## Photocopies

Photocopies of all articles abstracted in *Gas Abstracts*, except those enumerated here, are available from the Institute at cost:*

1) Russian Articles.—Abstracts are obtained from services specializing in this field. English translations can be supplied by arrangement with the appropriate abstractor.
2) U.S. Patents.—Printed copies can be secured at 25 cents each (remittance with order) from the Commissioner of Patents, Washington 25, D.C.
3) Books, Special Reports.—When a price is given in the abstract, these should be secured from a bookdealer or the publisher; when stated *free*, from the publisher.

### Types of Photocopies

Depending on the "tightness" of the binding (which determines whether pages can be laid flat without breaking the binding), and the color of the paper and ink used in the original being copied, photocopies may take any of several forms:

1. Positive paper prints made by the reflex process.
2. Positive paper prints enlarged by xerography from microfilm negatives.
3. Negative photostats.
4. Positive photostats.

Choice of the method used must necessarily rest with the Institute. All photocopies are approximately the same size as the original material.

### Cost of Service

The photocopy service charge is:

First 5 pages or fraction thereof of one article in one issue ..... $1.50

Each subsequent 4 pages or fraction thereof of the above one article in the same issue..... $1.00

Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

## Microfilm

Microfilm copies of articles abstracted in *Gas Abstracts* are likewise available at cost.* The material is photographed on 35 mm unperforated negative film at 5¢ per page, with a minimum of 50 pages, $2.50, per order. Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

## Bibliographies and Literature Searches

The library will prepare bibliographies and make literature searches on a cost basis plus a service charge. A comprehensive statement detailing the problem must be presented with the request.

## Gas Abstracts on Cards

The abstracts in each monthly issue are also printed individually on 5 x 8-inch cards. Each card bears at its top the author and subject headings under which it may be filed. As many copies of each card are supplied as there are headings on that card, enabling filing of the abstract under all of its headings, eliminating cross-indexing.

The annual subscription to *Gas Abstracts on Cards*, a mailing of 500-1000 cards each month, is $120.00 to U. S. addresses, $150.00 foreign.

Since the printing order for cards is based on the current number of subscribers, a subscription for this service commences with the month in which the order is received. Back numbers of *Gas Abstracts on Cards* are not available.

## Back Numbers of Gas Abstracts

In response to an increasing number of requests from utilities, colleges, and technical libraries which have only recently learned of the reference value of *Gas Abstracts*, the Institute has taken steps to make available single numbers, volumes, or complete files of this publication to date, starting with Vols. 1 (1945) and 2 (1946), some numbers of which are out of print.

The latter numbers are reproduced by a photoprinting process from copies in the Institute's libraries, and Vols. 1 and 2 can now be purchased at $35 per volume, unbound; single monthly numbers are offered at $3 each.

Vols. 3 to date are available at current subscription prices, $18 per volume to U. S. addresses, $22 foreign. Monthly numbers are $2 each.

---

*In requesting and accepting photocopies or microfilm copies, the applicant agrees to the following:

1. The applicant desires this duplication solely for use in lieu of loan or manual transcription. Responsibility for questions of copyright that might arise in this copying, and in the use of the copies, is assumed by the applicant.

2. The applicant understands that the Institute does not sell the photocopies, but merely performs the service of copying at the applicant's request; the fee paid is exclusively for such service and is established on the basis of no profit to the Institute.

3. The Institute reserves the right at its own discretion to decline to make photocopies requested, or to limit the number of copies, within the principle of fair use of copyrighted material.

# Publications Abstracted for GAS ABSTRACTS

*Air Conditioning, Heating and Ventilating*
*Air Engineering*
*Air Pollution Control Association, Journal of*
*American Chemical Society, Journal of*
*American Gas Association Monthly*
*American Gas Journal*
*American Institute of Chemical Engineers, Journal of*
*American Society of Mechanical Engineers, Transactions of*
*Engineering for Power, Journal of* (Series A)
*Engineering for Industry, Journal of* (Series B)
*Heat Transfer, Journal of* (Series C)
*Basic Engineering, Journal of* (Series D)
*Applied Mechanics, Journal of* (Series E)
*Analytical Chemistry*
*Appliance Manufacturer*
*Applied Chemistry, Journal of*
*Applied Mechanics Reviews*
*Applied Physics, Journal of*
*Applied Spectroscopy*
*ARS Journal*
*ASHRAE J.*
*Australian Journal of Applied Science*
*Australian Journal of Chemistry*

*Battelle Technical Review*
*Bituminous Coal Research*
*Brennstoff-Chemie* (German)
*British Coal Utilization Research Association Monthly Bulletin* and *Quarterly Gazette*
*Business Week*
*Butane-Propane News*

*Canadian Chemical Processing*
*Canadian Gas Journal*
*Canadian Journal of Chemical Engineering*
*Canadian Journal of Chemistry*
*Canadian Journal of Physics*
*Ceramics* (British)
*Chemical* and *Engineering Data, Journal of*
*Chemical* and *Engineering News*
*Chemical & Process Engineering*
*Chemical Documentation, Journal of*
*Chemical Education, Journal of*
*Chemical Engineering*
*Chemical Engineering Progress*
*Chemical Physics, Journal of*
*Chemical Processing*
*Chemical Reviews*
*Chemical Society, Journal of* (British)
*Chemical Society, Proceedings* (British)
*Chemical Week*
*Chemistry & Industry* (British)
*Chromatography, Journal of* (Netherlands)
*Coal-Heat*
*Coal Utilization*
*Coke and Gas* (British)
*Combustion*
*Combustion and Flame* (British)
*Compressed Air*
*Computers and Automation*
*Control Engineering*
*Corrosion*
*Corrosion Technology* (British)
*Cost Engineering*
*Cryogenics*

*Datamation*
*Design News*
*Drilling*

*Electrochemical Society, Journal of*
*Electronics*
*Engineers' Digest* (British)
*Erdöl und Kohle* (German)

*Faraday Society, Transactions of* (British)
*Fuel* (British)
*Fuel Efficiency* (British)
*Fueloil & Oil Heat*

*Gas*
*Gas Age*
*Gas Council Research Communications* (British)
*Gas Heat and Comfort Cooling*
*Gas Industries*
*Gas Journal* (British)
*Gas Service and Domestic Coke*
*Gas Times* (British)
*Gas- und Wasserfach* (German)
*Gas World* (British)
*Gazovaya Promyshlennost* (Russian)

*Heating, Piping & Air Conditioning*

*Independent Petroleum Monthly*
*Industrial and Engineering Chemistry*
*Industrial Finishing* (British)
*Industrial Gas* (American)
*Industrial Gas* (British)
*Industrial Heating*
*Industrial Research*
*Industries du Gaz, Journal des* (French)
*Institute of Fuel, Journal of* (British)
*Institute of Gas Technology Research Bulletins*
*Institute of Petroleum, Journal of* (British)
*Institution of Gas Engineers Journal* (British)
*Instrumentation*
*Instruments and Control Systems*
*Izvestiva Akademii Nauk S. S. S. R. Otdelenie Khimicheskikh Nauk* (Russian)

*Khimiya i Tekhnologiya Topliva i Masel* (Russian)

*LP-Gas*

*Materials Research & Standards*
*Mechanical Engineering*
*Mechanical Power* (British)
*Metals, Journal of*

*National Aeronautics and Space Administration Memorandum*
*National Fire Protection Association Quarterly*
*National Gas Bulletin of Australia*
*National Petroleum News*
*Nuclear Science and Engineering*
*Nucleonics*

*Oil and Gas Journal*
*Organic Chemistry, Journal of*

*Petro/Chem Engineer*
*Petroleum* (British)
*Petroleum Engineer, The* (Drilling and Producing)
*Petroleum Management*
*Petroleum Refiner*
*Petroleum Technology Journal of*
*Petroleum Times*
*Physical Chemistry, Journal of*
*Physics and Chemistry of Solids* (British)
*Physics of Fluids* (British)
*Pipeline Engineer*
*Pipe Line Industry*
*Pipeline News*
*Power*
*Producers Monthly*
*Product Engineering*
*Progress* (Pakistan)
*Public Utilities Fortnightly*

*Research/Development*
*Research, Journal of, A. Physics and Chemistry*
*Research, Journal of, B Mathematics and Mathematical Physics*
*Research, Journal of, C. Engineering and Instrumentation*
*Review of Scientific Instruments*
*Revue Generale du Gaz* (Belgian)
*Rivista dei Combustibili* (Italian)

*Science*
*Scientific & Industrial Research, Journal of, A. General* (India)
*Scientific & Industrial Research, Journal of, B. Physical Sciences* (India)
*Scientific Instruments, Journal of* (British)
*Society of Petroleum Engineers, Journal of*
*Stroitel'stvo Truboprovodov* (Russian)
*Svenska Gasverksföreningens Månadsblad* (Swedish)

*Technical News Bulletin*

*U.S. Bureau of Mines Bulletins, Information Circulars* and *Reports of Investigations*
U.S. Patents
*Uspekhi Khimii* (Russian)

*World Oil*
*World Petroleum*